Alfred D. Flinn

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TWENTY-SIXTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

BOSTON:
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1895.

MEMBERS OF THE BOARD.

1894–1895.

HENRY P. WALCOTT, M.D., *Chairman*,	of Cambridge.
HIRAM F. MILLS, C.E.,	of Lawrence.
FRANK W. DRAPER, M.D.,	of Boston.
GERARD C. TOBEY, Esq.,	of Wareham.
JAMES W. HULL,	of Pittsfield.
CHARLES H. PORTER,	of Quincy.
JOSEPH W. HASTINGS, M.D.,*	of Warren.

Secretary.

SAMUEL W. ABBOTT, M.D.

Engineer.

F. P. STEARNS, C.E.

* Deceased.

CONTENTS.

GENERAL REPORT.

The contents of the present volume comprise a report of the general work of the State Board of Health for the year ending Sept. 30, 1894, and of that which relates to Water Supply and Sewerage for the calendar year 1894.

This first portion, the general report, paged in Roman numerals, includes a brief statement of the work done under the statutes which define the work of the Board, and contains a summary of the vital statistics of the State for the year 1893.

The second part of the report, paged in Arabic numerals, contains the fuller details of the work of the Board, under the acts relating to Water Supply and Sewerage, Food and Drug Inspection, Reporting of Infectious Diseases and such papers relating to special topics as the Board has deemed it desirable to publish.

The following members comprised the Board in 1894: —

HENRY P. WALCOTT, *Chairman.*

FRANK W. DRAPER.	JOSEPH W. HASTINGS.
HIRAM F. MILLS.	GERARD C. TOBEY.
JAMES W. HULL.	CHARLES H. PORTER.

C. H. Porter of Quincy was appointed in February, 1894, to fill the place made vacant by the death of Dr. Jones. Dr. J. W. Hastings' term expired May, 1894, and he was reappointed for seven years.

During the year 1894, in addition to the regular routine work of the Board, the following special lines of work have been prosecuted: —

The investigations relating to a general supply of water for the metropolitan district, authorized by an act of 1893, were completed, and a report upon the same was transmitted to the Legislature.

Under the provisions of chapter 426 of the Acts of 1894, a contract was made with the Eastern Dredging Company for the purpose of dredging certain portions of the Concord and Sudbury rivers, and the work is now progressing.

Under the organic act creating the Board and requiring it to "take cognizance of the interests of health and life among the citizens of the Commonwealth," the Board has taken measures to provide a supply of antitoxine, for use throughout the Commonwealth, for the purpose of diminishing the mortality from diphtheria.

Further investigations relating to the reduction in the prevalence of trichinosis among swine will be found detailed in a communication from Professor Mark of Harvard University.

Progress has also been made in the investigations relating to the prevalence of malarial infection in the Charles River valley.

Infectious Diseases.

The principal outbreak of infectious disease worthy of note which occurred during the year was the epidemic of small-pox, which began in the previous year, 1893, and reached its height in April, 1894, but had entirely subsided before midsummer. The principal data relative to the earlier period of this epidemic are detailed in the report of 1893. The following statement relates to the closing period of the epidemic, comprising the first half of 1894. A summary of the ten-year period, 1885–94, is also presented.

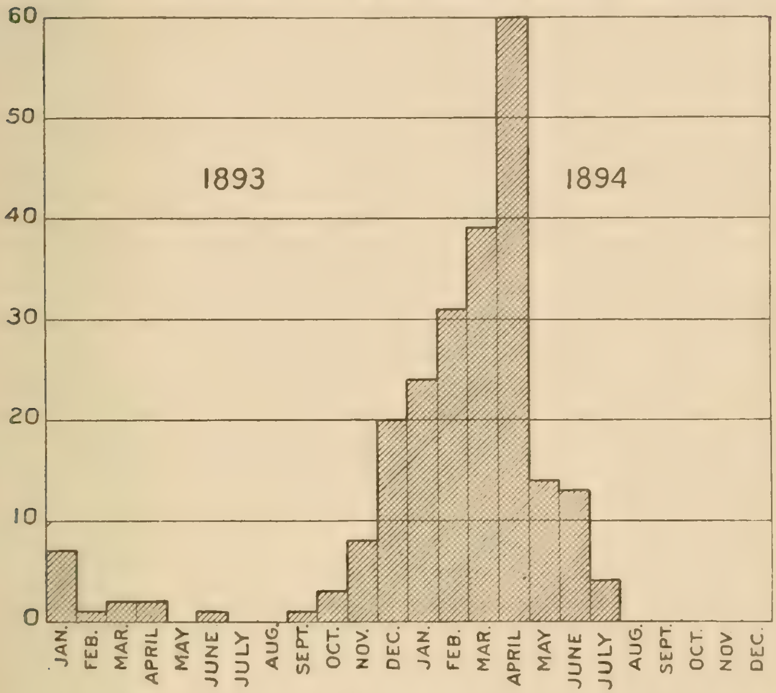
Small-pox.

The epidemic of small-pox of 1893–94 culminated in April, 1894, 60 cases being reported to the Board during that month. The following table presents the monthly record of reported cases for the two years, 1893–94: —

Reported Cases of Small-pox, Massachusetts, 1893–94.

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1893, ...	7	1	2	2	0	1	0	0	1	3	8	20	44
1894, ...	24	31	39	60	14	13	4	0	0	0	0	0	185

Reported Cases of Small-pox in Massachusetts by Months, 1893–94.



By this table and diagram, it appears that 201 cases, or nearly nine-tenths of all that occurred in the two years, were reported in the seven months ending with June, 1894. In most of the previous epidemics of the past thirty years the height of the epidemic has come in midwinter. The following table presents a detailed statement of the cases reported during the year 1894, as copied from the individual returns sent to the office of the Board: —

Cases of Small-pox reported to the State Board of Health in 1894, under the Provisions of Chapter 138 of the Acts of 1893.

Number.	Date of Report.	Place of Occurrence.	Nationality of Patient.	Occupation.	Age.	Sex.	Previously Vaccinated.	Number of Scars.	Deaths.
1	Jan. 1,	Boston, . .	United States, .	Iron moulder, . .	40 years.	M.	?	–	1
2	Jan. 2,	Lowell, . .	Irish, . . .	Mill operative, .	24 "	F.	No.	–	1
3	Jan. 2,	Lowell, . .	Irish, . . .	– –	22 "	F.	Yes.	1	–
4	Jan. 2,	Lowell, . .	Irish, . . .	– –	18 "	F.	Yes.	1	–
5	Jan. 4,	Boston, . .	United States, .	Night watchman, .	35 "	M.	No.	–	–

Number.	Date of Report.	Place of Occurrence.	Nationality of Patient.	Occupation.	Age.	Sex.	Previously Vaccinated.	Number of Scars.	Deaths.
6	Jan. 5,	Boston, . .	Br. Provinces, .	Teamster, . .	25 years.	M.	No.	-	1
7	Jan. 5,	Boston, . .	Br. Provinces, .	Teamster, . .	35 "	M.	No.	-	1
8	Jan. 5,	Worcester, .	Irish, . .	Tanner, . . .	37 "	M.	Yes.	1	-
9	Jan. 6,	Lowell, . .	Irish, . .	Mill operative, .	26 "	F.	No.	-	1
10	Jan. 6,	Lowell, . .	Irish, . .	Mill operative, .	19 "	F.	Yes.	-	-
11	Jan. 6,	Lowell, . .	Irish, . .	Milk pedler, . .	21 "	M.	?	-	1
12	Jan. 8,	Boston, . .	Irish, . .	Carpenter, . .	29 "	M.	Yes.	2	-
13	Jan. 9,	Boston, . .	United States, .	School boy, . .	14 "	M.	Yes.	1	-
14	Jan. 12,	Methuen, . .	Br. Provinces, .	Laborer, . . .	22 "	M.	No.	-	-
15	Jan. 12,	Methuen, . .	Scotland, . .	- -	7 "	F.	No.	-	-
16	Jan. 16,	Marlborough, .	Br. Provinces, .	Book-keeper, . .	28 "	M.	Yes.	1	-
17	Jan. 18,	Brookline, .	Br. Provinces, .	Domestic, . .	23 "	F.	No.	-	-
18	Jan. 18,	Boston, . .	United States, .	Wife of No. 5, .	25 "	F.	-	-	-
19	Jan. 21,	Boston, . .	United States, .	School boy, . .	9 "	M.	No.	-	-
20	Jan. 22,	Boston, . .	United States, .	- -	26 "	F.	Yes.	1	1
21	Jan. 28,	Lowell, . .	Br. Provinces, .	Nurse, . . .	45 "	F.	No.	-	-
22	Jan. 29,	Brookline, .	United States, .	Draughtsman, . .	23 "	M.	Yes.	-	-
23	Jan. 22,	Worcester, .	United States, .	Physician, . .	30 "	M.	Yes.	1	-
24	Jan. 23,	Boston, . .	United States, .	Housewife, . .	50 "	F.	Yes.	1	-
25	Feb. 1,	Boston, . .	Irish, . .	Housewife, . .	27 "	F.	Yes.	1	-
26	Feb. 1,	Boston, . .	Swede, . .	Barber, . . .	21 "	M.	No.	-	-
27	Feb. 8,	Holyoke, . .	United States, .	Rag worker, . .	29 "	F.	Yes.	-	-
28	Feb. 15,	Worcester, .	Irish, . .	Nurse, . . .	27 "	F.	Yes.	4	-
29	Feb. 16,	Holyoke, . .	United States, .	- -	6 "	M.	No.	-	-
30	Feb. 16,	Holyoke, . .	United States, .	- -	3 "	F.	No.	-	1
31	Feb. 16,	Holyoke, . .	United States, .	- -	8 "	M.	No.	-	-
32	Feb. 16,	Holyoke, . .	United States, .	- -	6 "	M.	No.	-	-
33	Feb. 16,	Holyoke, . .	United States, .	- -	1 y. 4 m.	M.	No.	-	-
34	Feb. 18,	Boston, . .	Br. Provinces, .	Laborer, . . .	34 years.	M.	Yes.	1	1
35	Feb. 18,	Boston, . .	United States, .	Waiter, . . .	24 "	F.	No.	-	1
36	Feb. 18,	Boston, . .	United States, .	Engineer, . .	45 "	M.	Yes.	1	-
37	Feb. 19,	Boston, . .	United States, .	Housewife, . .	32 "	F.	No.	-	-
38	Feb. 19,	Boston, . .	United States, .	- -	14 days.	M.	No.	-	1
39	Feb. 19,	Boston, . .	United States, .	Housewife, . .	38 years.	F.	Yes.	1	-
40	Feb. 20,	Boston, . .	United States, .	- -	4 "	M.	No.	-	1
41	Feb. 20,	Boston, . .	Irish, . .	- -	17 "	M.	Yes.	1	-
42	Feb. 20,	Boston, . .	England, . .	Mechanic, . .	27 "	M.	Yes.	1	-
43	Feb. 21,	Boston, . .	Br. Provinces, .	Moulder, . . .	28 "	M.	Yes.	1	-

Number.	Date of Report.	Place of Occurrence.	Nationality of Patient.	Occupation.	Age.	Sex.	Previously Vaccinated.	Number of Scars.	Deaths.
44	Feb. 22,	Lawrence, .	United States, .	– –	10 weeks.	F.	No.	–	–
45	Feb. 23,	Boston, . .	United States, .	Moulder, . . .	51 years.	M.	Yes.	1	–
46	Feb. 23,	Boston, . .	United States, .	Carpenter, . .	37 "	M.	No.	–	1
47	Feb. 23,	Holyoke, . .	Br. Provinces, .	Mill operative, .	23 "	F.	No.	–	–
48	Feb. 24,	Boston, . .	Germany, .	Housewife, . .	36 "	F.	No.	–	1
49	Feb. 25,	Boston, . .	United States, .	– –	35 "	F.	Yes.	1	1
50	Feb. 26,	Boston, . .	Scotland, . .	Housewife, . .	37 "	F.	No.	–	–
51	Feb. 26,	Boston, . .	United States, .	– –	3 "	F.	No.	–	–
52	Feb. 26,	Boston, . .	United States, .	Carpenter, . .	47 "	M.	Yes.	1	–
53	Feb. 26,	Boston, . .	United States, .	Yachtsman, . .	29 "	M.	Yes.	1	–
54	Feb. 27,	Boston, . .	United States, .	– –	15 "	F.	–	–	–
55	Feb. 27,	Boston, . .	United States, .	– –	38 "	M.	Yes.	2	–
56	Mar. 2,	Boston, . .	United States, .	Laborer, . . .	27 "	M.	Yes.	1	–
57	Mar. 3,	Boston, . .	United States, .	– –	3 "	F.	Yes.	2	–
58	Mar. 5,	Boston, . .	Irish, . .	Laborer, . . .	24 "	M.	Yes.	2	–
59	Mar. 5,	Boston, . .	Irish, . .	Laborer, . . .	47 "	M.	Yes.	1	–
60	Mar. 6,	Boston, . .	United States, .	Bootblack, . .	60 "	M.	Yes.	1	–
61	Mar. 7,	Boston, . .	United States, .	– –	25 "	F.	Yes.	2	–
62	Mar. 7,	Boston, . .	United States, .	– –	52 "	M.	?	–	–
63	Mar. 7,	Boston, . .	United States, .	– –	1y. 3m.	M.	No.	–	–
64	Mar. 11,	Lynn, . .	United States, .	Shoe operator, .	19 years.	F.	No.	–	1
65	Mar. 12,	Waltham, . .	United States, .	– –	1y. 6m.	F.	No.	–	–
66	Mar. 10,	Boston, . .	United States, .	Laborer, . . .	21 years.	M.	No.	–	1
67	Mar. 10,	Boston, . .	Irish, . .	Laborer, . . .	26 "	M.	Yes.	1	–
68	Mar. 10,	Boston, . .	United States, .	Laborer, . . .	42 "	M.	Yes.	1	1
69	Mar. 13,	Boston, . .	United States, .	– –	8 "	F.	No.	–	–
70	Mar. 13,	Holyoke, . .	Fr. Canadian, .	– –	8 "	M.	No.	–	–
71	Mar. 13,	Holyoke, . .	Fr. Canadian, .	– –	6 "	F.	No.	–	–
72	Mar. 13,	Holyoke, . .	Fr. Canadian, .	– –	4 "	F.	No.	–	–
73	Mar. 13,	Holyoke, . .	Scotland, . .	Engineer, paper mill,	47 "	M.	Yes.	1	–
74	Mar. 13,	Holyoke, . .	Scotland, . .	Child of No. 73, .	2 "	M.	No.	–	–
75	Mar. 13,	Holyoke, . .	United States, .	– –	7 "	M.	No.	–	–
76	Mar. 13,	Holyoke, . .	United States, .	Bricklayer, . .	42 "	M.	No.	–	1
77	Mar. 15,	Holyoke, . .	Fr. Canadian, .	– –	4 "	M.	No.	–	–
78	Mar. 16,	Boston, . .	United States, .	– –	46 "	F.	Yes.	2	–
79	Mar. 16,	Boston, . .	United States, .	Domestic, . .	24 "	F.	No.	–	–
80	Mar. 17,	Boston, . .	United States, .	– –	2y. 6m.	M.	No.	–	–
81	Mar. 18,	Holyoke, . .	Br. Provinces, .	– –	5 years.	M.	Yes.	?	–

Number.	Date of Report.	Place of Occurrence.	Nationality of Patient.	Occupation.	Age.	Sex.	Previously Vaccinated	Number of Scars.	Deaths.
82	Mar. 20,	Boston, . .	United States, .	- -	6 mos.	M.	No.	-	1
83	Mar. 20,	Boston, . .	United States, .	- -	6 "	F.	No.	-	1
84	Mar. 20,	Boston, . .	Ireland, . .	- -	36 years.	M.	Yes.	2	-
85	Mar. 20,	Boston, . .	Ireland, . .	Laborer, . . .	46 "	M.	Yes.	1	-
86	Mar. 21,	Boston, . .	United States, .	- -	24 "	F.	Yes.	1	-
87	Mar. 21,	Melrose, . .	United States, .	Clerk, . . .	25 "	M.	Yes.	1	-
88	Mar. 24,	Boston, . .	United States, .	- -	5 "	M.	No.	-	-
89	Mar. 24,	Boston, . .	United States, .	- -	1 mo.	F.	No.	-	1
90	Mar. 27,	Boston, . .	United States, .	- -	2 mos.	M.	No.	-	1
91	Mar. 28,	Boston, . .	United States, .	- -	28 years.	F.	?	-	1
92	Mar. 30,	Boston, . .	United States, .	- -	6 "	F.	No.	-	-
93	Mar. 31,	Boston, . .	United States, .	House servant, .	23 "	F.	?	-	-
94	Mar. 31,	Boston, . .	Br. Provinces, .	Teamster, . .	55 "	M.	?	?	1
95	Apr. 2,	Boston, . .	Br. Provinces, .	Housekeeper, . .	28 "	F	No.	-	-
96	Apr. 3,	Boston, . .	Br. Provinces, .	Teamster, . .	26 "	M.	Yes.	1	1
97	Apr. 5,	Boston, . .	United States, .	Morocco worker, .	42 "	M.	Yes.	1	-
98	Apr. 7,	Boston, . .	United States, .	Laborer, . . .	26 "	M.	No.	-	-
99	Apr. 7,	Boston, . .	Br. Provinces, .	- -	38 "	M.	No.	-	1
100	Apr. 10,	Chicopee, . .	Ireland, . .	Laborer, . . .	-	M.	Yes.	-	-
101	Apr. 11,	Chicopee, . .	France, . .	- -	26 years.	M.	-	-	-
102	Apr. 11,	Chicopee, . .	Fr. Canadian, .	- -	20 "	F.	-	-	-
103	Apr. 11,	Holyoke, . .	Fr. Canadian, .	Mill operative, .	21 "	M.	No.	-	-
104	Apr. 11,	Holyoke, . .	Fr. Canadian, .	Mill operative, .	17 "	M.	No.	-	-
105	Apr. 13,	Holyoke, . .	Fr. Canadian, .	- -	2 y. 6 m.	M.	No.	-	-
106	Apr. 16,	Boston, . .	Br. Provinces, .	- -	37 years.	F.	No.	-	-
107	Apr. 15,	Holyoke, . .	France, . .	Weaver, . . .	19 "	F.	Yes.	-	1
108	Apr. 15,	Holyoke, . .	France, . .	- -	4 "	M.	No.	-	-
109	Apr. 16,	Holyoke, . .	Fr. Canadian, .	Paper-mill operative,	22 "	M.	No.	-	-
110	Apr. 16,	Holyoke, . .	Fr. Canadian, .	Mill operative, .	14 "	F.	Yes.	2	-
111	Apr. 17,	Stoneham, .	United States, .	Housekeeper, . .	40 "	F.	Yes.	1	-
112	Apr. 18,	Boston, . .	Br. Provinces, .	Waiter, . . .	32 "	M.	No.	-	1
113	Apr. 18,	Holyoke, . .	Germany, .	School girl, . .	10 "	F.	No.	-	-
114	Apr. 18,	Holyoke, . .	United States, .	- -	27 "	F.	Yes.	-	-
115	Apr. 20,	Boston, . .	Scotland, . .	Housewife, . .	35 "	F.	Yes.	1	-
116	Apr. 20,	Holyoke, . .	Fr. Canadian, .	- -	2 "	M.	No.	-	-
117	Apr. 23,	Boston, . .	United States, .	Clerk, . . .	18 "	M.	Yes.	2	-
118	Apr. 22,	Holyoke, . .	France, . .	- -	6 "	F.	No.	-	-
119	Apr. 12,	Chicopee, . .	Ireland, . .	- -	1 y. 2 m.	M.	No.	-	1

Number.	Date of Report.	Place of Occurrence.	Nationality of Patient.	Occupation.	Age.	Sex.	Previously Vaccinated.	Number of Scars.	Deaths.
120	Apr. 5,	Chicopee, .	United States, .	- -	3 y. 6 m.	M.	No.	-	-
121	Apr. 5,	Chicopee, .	Scotland, .	Mill operative,	27 years.	F.	Yes.	2	-
122	Apr. 12,	Chicopee, .	United States, .	Laborer, .	17 "	M.	Yes.	1	-
123	Apr. 12,	Chicopee, .	Ireland, .	Laborer, .	49 "	M.	Yes.	1	-
124	Apr. 12,	Chicopee, .	United States, .	School boy,	14 "	M.	Yes.	1	-
125	Apr. 12,	Chicopee, .	England, .	Mill operative,	48 "	M.	Yes.	1	-
126	Apr. 12,	Chicopee, .	United States, .	School girl,	12 "	F.	No.	-	-
127	Apr. 12,	Chicopee, .	Ireland, .	Nickel plater, .	23 "	M.	Yes.	1	-
128	Apr. 12,	Chicopee, .	Br. Provinces, .	School girl,	17 "	F.	No.	-	-
129	Apr. 12,	Chicopee, .	Br. Provinces, .	School girl,	15 "	F.	No.	-	-
130	Apr. 12,	Chicopee, .	Br. Provinces, .	Painter, .	42 "	M.	Yes.	1	-
131	Apr. 12,	Chicopee, .	Fr. Canadian, .	- -	28 "	F.	No.	-	1
132	Apr. 14,	Chicopee, .	Ireland, .	Mill operative,	20 "	F.	No.	-	-
133	Apr. 14,	Chicopee, .	Br. Provinces, .	Weaver, .	24 "	M.	No.	-	-
134	Apr. 14,	Chicopee, .	Fr. Canadian, .	Barber, .	22 "	M.	Yes.	1	-
135	Apr. 15,	Chicopee, .	Ireland, .	School girl,	7 "	F.	Yes.	0	-
136	Apr. 15,	Chicopee, .	Ireland, .	Laborer, .	31 "	M.	Yes.	4	-
137	Apr. 15,	Chicopee, .	United States, .	Mill operative,	17 "	F.	No.	-	-
138	Apr. 15,	Chicopee, .	Ireland, .	Mill operative,	29 "	F.	No.	-	-
139	Apr. 17,	Chicopee, .	Ireland, .	Mill operative,	32 "	F.	Yes.	2	-
140	Apr. 17,	Chicopee, .	Fr. Canadian, .	Mill operative,	27 "	F.	Yes.	1	-
141	Apr. 25,	Worcester,	English, .	Harness maker,	23 "	M.	Yes.	2	-
142	Apr. 25,	Worcester,	Swede (U. S.), .	Housewife,	39 "	F.	No.	-	-
143	Apr. 25,	Worcester,	England, .	Housewife,	30 "	F.	Yes.	2	-
144	Apr. 25,	Worcester,	England, .	Harness maker,	19 "	M.	Yes.	2	-
145	Apr. 26,	Chicopee, .	Fr. Canadian, .	Mill operative,	26 "	M.	?	0	-
146	Apr. 26,	Boston,	United States, .	- -	10 "	M.	No.	-	-
147	Apr. 27,	Boston,	United States, .	Stone cutter, .	29 "	M.	No.	-	-
148	Apr. 28,	Chicopee, .	Irish, .	Housekeeper, .	55 "	F.	Yes.	?	-
149	Apr. 27,	Boston,	United States, .	Physician,	30 "	M.	Yes.	1	-
150	Apr. 29,	Boston,	United States, .	- -	3 mos.	M.	No.	-	-
151	Apr. 30,	Boston,	United States, .	Laborer, .	41 years.	M.	Yes.	1	-
152	Apr. 30,	Holyoke, .	United States, .	Tramp, .	24 "	M.	Yes.	-	-
153	Apr. 30,	Holyoke, .	Fr. Canadian, .	Butcher, .	29 "	M.	Yes.	1	-
154	May 2,	Boston,	United States, .	Plumber, .	22 "	M.	Yes.	1	-
155	May 4,	Natick,	United States, .	Bartender,	-	M.	Yes.	-	-
156	May 7,	Worcester,	France, .	Tramp, .	41 "	M.	-	?	-
157	May 7,	Worcester,	German (U. S.),	Tramp, .	19 "	M.	No.	-	-
158	May 8,	Holyoke, .	Fr. Canadian, .	Mill operative, .	27 "	M.	No.	-	-

Number.	Date of Report.	Place of Occurrence.	Nationality of Patient.	Occupation.	Age.	Sex.	Previously Vaccinated.	Number of Scars.	Deaths.
159	May 10,	Worcester, .	England, . .	Housewife, . .	38 years.	F.	Yes.	1	–
160	Apr. 29,	Chicopee, . .	United States, .	School girl, . .	8 "	F.	No.	–	–
161	May 15,	Randolph, . .	United States, .	Housekeeper, . .	54 "	F.	Yes.	–	–
162	May 14,	Boston, . .	United States, .	Telegraph operator,	24 "	M.	Yes.	4	–
163	May 18,	State Almshouse,	United States, .	Physician, . .	27 "	M.	Yes.	2	–
164	May 25,	State Almshouse,	United States, .	Mill operative, .	27 "	M.	No.	–	1
165	May 26,	Worcester, .	United States, .	House painter, .	58 "	M.	Yes.	1	–
166	May 39,	State Almshouse,	United States, .	Medical student and nurse.	22 "	M.	No.	–	–
167	May 31,	Worcester, .	United States, .	Housekeeper, . .	44 "	F.	–	?	–
168	May 23,	Dalton, . .	United States, .	Paper-mill operative rag cutter.	22 "	F.	No.	–	–
169	June 4,	Quincy, . .	United States, .	Waiter, . . .	46 "	M.	?	?	–
170	June 5,	Springfield, .	United States, .	– –	1 year.	F.	No.	–	–
171	June 5,	Springfield, .	United States, .	– –	4 years.	M.	No.	–	–
172	June 5,	Springfield, .	United States, .	– –	3 "	M.	No.	–	–
173	June 9,	Chelsea, . .	United States, .	– –	20 "	F.	Yes.	1	–
174	June 9,	Chelsea, . .	United States, .	– –	2 y. 6 m.	F.	No.	–	–
175	June 9,	Chelsea, . .	England, . .	Rubber worker, .	30 years.	M.	Yes.	2	–
176	June 9,	Chelsea, . .	United States, .	– –	5 y. 6 m.	M.	No.	–	–
177	June 9,	Chelsea, . .	United States, .	– –	3 y. 6 m.	F.	No.	–	–
178	June 9,	Chelsea, . .	United States, .	– –	21 years.	F.	Yes.	2	–
179	June 16,	State Almshouse,	United States, .	Nurse, . . .	30 "	F.	?	?	–
180	June 20,	Worcester, .	England, . .	Machinist, . .	58 "	M.	Yes.	0	–
181	June 20,	Worcester, .	United States, .	– –	61 "	M.	Yes.	1	–
182	July 7,	Worcester, .	United States, .	Book-keeper, . .	20 "	M.	Yes.	1	–
183	July 7,	Worcester, .	United States, .	School teacher, .	24 "	F.	Yes.	1	–
184	July 16,	Worcester, .	United States, .	Overseer public institution.	37 "	M.	Yes.	2	–
185	July 3,	Chelsea, . .	United States, .	– –	30 "	F.	Yes.	–	–

Persons vaccinated for the first time within ten days of date of report are not accounted as vaccinated.

Notes. — 3. Vaccinated in infancy; very faint scar. 4, 8, 10, 12, 20, 23, 24, 25, 27, 36, 39, 41, 42, 43, 45, 49, 52, 53, 55, 56, 58, 59, 61, 67, 68, 73, 84, 85, 86, 87, 97, 107, 111, 114, 115, 117, 121, 123, 125, 134, 141, 143, 144, 149, 151, 152, 154, 161, 163, 165, 180, 183. Vaccinated in infancy. 5, 9, 18. Vaccinated a few days before date of report, but too late to be of service. 13. One imperfect scar. 16. Vaccinated ten years ago. 21. Had had small-pox when younger. 22. Vaccinated 14 years ago. 11. Says he was vaccinated in childhood, but probably it did not "take." 28. Vaccinated six weeks previous. 29, 30. One week previous. 34. Said to have been vaccinated in infancy; scar doubtful. 54, 57. Vaccinated a few days before illness. 60. Forty-five years ago. 91, 94. Said to have been vaccinated in infancy. 96. Said to have been vaccinated; imperfect scar. 110. Vaccinated six years ago. 113. Father worked in paper mill. 122. Vaccinated ten years ago. 124. Vaccinated five years ago. 127. Vaccination seven years ago. 135. Vaccinated one year ago. 136. Vaccinated two years ago. 140. Imperfect scar. 164. Vaccinated unsuccessfully. 153. Vaccinated three years ago. 159. Vaccinated one and a half years ago. 162. Vaccinated thrice. 173. Vaccinated twelve years ago. 175. Eight years ago. 178. Twelve or fourteen years ago. 181. Vaccinated thirty-eight years ago. 182. Twelve years ago. 184. Eight years ago. 185. Twenty years ago.

The cases and deaths reported in the foregoing table and in the table on page xviii, together with similar tables which have appeared in previous reports, do not include quite all which occurred in these ten years, since the law which requires the reporting of cases to the State Board of Health only provides a penalty in the case of those persons not reported to the Board who have no settlement in the Commonwealth.

As compared with the epidemic of 1872–73, and the still greater prevalence in pre-vaccination times, the recent outbreak is scarcely worthy of mention. But the collection of more careful records during the past ten years furnishes data for conclusions as to the effect of better methods of control.

The first table on page xvi shows the comparative prevalence of small-pox in Massachusetts for the past forty years. The data presented are the deaths in each year, the percentage of the total mortality, and the death-rate per 10,000 of the living population.

According to this table, it appears that there have been 4,548 deaths from small-pox in Massachusetts in the forty years ending with 1894. Of this total of 4,548 deaths in the forty-year period, 4,231 occurred in the first twenty years (1855–74), and 317 in the second twenty years (1875–94). The ratio in the first instance was 160 per million of the population annually, and in the second twenty years eight per million. For the decade ending with 1894 the mortality from this cause was less than four per million annually.

The next table presents the number of deaths from small-pox at each period of life, as compared with the total mortality from this cause. For the sake of comparison, similar facts are presented for populations living in the seventeenth and eighteenth centuries.

Small-pox in Massachusetts. — Forty Years (1855–94).

Years.	Deaths from Small-pox.	Percentage of Total Mortality.	Ratio per 10,000 of Living Population.	Years.	Deaths from Small-pox.	Percentage of Total Mortality.	Ratio per 10,000 of Living Population.
1855,	325	1.56	2.9	1875,	34	.09	.2
1856,	140	.68	1.2	1876,	31	.09	.2
1857,	23	.11	.2	1877,	24	.08	.14
1858,	12	.10	.1	1878,	2	.007	.012
1859,	255	1.22	2.1	1879,	7	.02	.04
1860,	334	1.45	2.7	1880,	38	.11	.21
1861,	33	.14	.3	1881,	47	.13	.25
1862,	40	.17	.3	1882,	45	.12	.24
1863,	42	.15	.3	1883,	5	.01	.03
1864,	242	.84	1.9	1884,	3	.008	.01
1865,	221	.84	1.7	1885,	19	.05	.10
1866,	141	.59	1.1	1886,	–	–	–
1867,	196	.82	1.5	1887,	3	.007	.015
1868,	20	.08	.2	1888,	8	.019	.04
1869,	59	.22	.4	1889,	6	.014	.03
1870,	131	.48	.9	1890,	1	.002	.004
1871,	294	1.05	1.9	1891,	1	.002	.004
1872,	1,029	2.94	6.7	1892,	2	.004	.01
1873,	668	1.97	4.3	1893,	9	.02	.04
1874,	26	.08	.2	1894,	32	.06	.13
Totals,	4,231	–	–	Totals,	317	–	–
Averages,	–	.83	1.6	Averages,	–	.04	.08

Deaths from Small-pox by Age Periods. — Distribution of 1,000 Deaths.

Ages.	Geneva, 1580-1760.	Kilmarnock (Scotland), 1728-64.	Massachusetts, 1861-93.
Under 5 years,	805.5	942	327
5 to 10 years,	155.5	34	69
10 to 20 years,	26.5	5	118
20 to 30 years,	10.	5	265
30 to 40 years.	2.5	–	101
40 and upward,		–	107
Not stated,	–	14	13
	1,000	1,000	1,000

Statistics giving deaths by ages are not abundant for years prior to 1800. The foregoing statistics, from authentic records of Geneva and from the very carefully kept record of a town clerk in a Scotch village, are believed to be trustworthy. A comparison of these figures for periods prior to 1800 with the table for Massachusetts for a recent period shows that a very marked change has taken place in the comparative mortality at different ages, and that some influence has been operative to effect a very decided change; so that small-pox, which was almost exclusively a children's disease prior to 1800, has in recent times undergone a transformation, from the operation of some cause or other. This change has not taken place, so far as any records show, in the case of any other disease.

In Geneva, from 1580 to 1760, out of every 1,000 deaths from small-pox, 961 were those of children under ten years of age; and in Kilmarnock during the thirty-six years (1728–64) 976 out of each 1,000 deaths from small-pox were also those of children under ten.

In Massachusetts, on the contrary, for the period 1861–93, but little more than one-third (396 out of 1,000) of all deaths from small-pox were those of children under ten, and the majority were those of persons over ten years old. The number of such deaths between the ages of twenty and thirty was more than double the number of deaths between ten and twenty.

Now, this very decided change in the incidence of small-pox at different age periods, a change which has not taken place in the case of any other disease, can only be explained by some influence which is exerted upon small-pox, but not upon other diseases; and this factor is the practice of vaccination.

When the population of a large city invaded by small-pox is subjected to a critical investigation, as was done by Dr. Barry in his searching examination of the population of Sheffield, Eng., in 1887, it was found to be possible to contrast the unvaccinated with the vaccinated population living under like conditions in the same city; and the result was precisely similar to that which appears in comparing a community living in the last century before vaccination was practised with a vaccinated community living in the present century under an invasion of small-pox.

Had the 327 infants in each 1,000 who died of small-pox in Massachusetts in the period 1861–93 been successfully vaccinated, the contrast between the column for Massachusetts and the two pre-

ceding columns taken from pre-vaccination periods would undoubtedly have been much more striking, since the death from small-pox of a successfully vaccinated infant is an almost unknown event.

As the protection afforded by primary vaccination begins to wane, and this well-known immunity is not re-established by re-vaccination, the deaths begin to increase, as is shown in the column for Massachusetts by the figures 69, 118 and 265 for the successive age periods 5–10, 10–20, 20–30, these deaths being made up partly of unvaccinated persons who had not been exposed to small-pox in infancy, and partly of those who had been vaccinated in infancy, but had never submitted themselves to re-vaccination.

During the past ten years very careful records have been kept, in consequence of a statute of 1883, requiring immediate notice of all cases of small-pox to the State authorities. From these records it has been possible to collect definite evidence relative to the protection afforded by vaccination in this Commonwealth. The following table presents a summary of the cases: —

Small-pox in Massachusetts, 1885–94. — Comparative Fatality of the Vaccinated and Unvaccinated.*

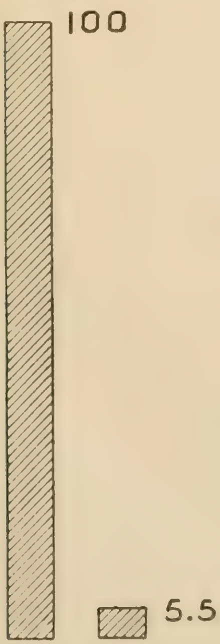
Years.	Totals.			Vaccinated.			Unvaccinated.			Unknown.		
	Cases.	Deaths.	Per Cent.	Cases.	Deaths.	Per Cent.	Cases.	Deaths.	Per Cent.	Cases.	Deaths.	Per Cent.
1885, . .	32	11	–	7	–	–	13	9	–	12	2	–
1886, . .	3	1	–	1	–	–	1	1	–	1	–	–
1887, . .	12	3	–	6	–	–	5	2	–	1	1	–
1888, . .	32	5	–	15	1	–	13	3	–	4	1	–
1889, . .	16	4	–	11	1	–	3	1	–	2	2	–
1890, . .	6	1	–	2	–	–	2	–	–	2	1	–
1891, . .	5	1	–	1	–	–	3	1	–	1	–	–
1892, . .	19	2	–	7	–	–	10	1	–	2	1	–
1893, . .	47	9	–	11	–	–	29	8	–	7	1	–
1894, . .	185	32	–	84	6	–	86	22	–	15	4	–
	357	69	19.3	145	8	5.5	165	48	29.1	47	13	27.4

* The reasons for the slight discrepancy between this table and that which is given on page xvi are stated on page xv.

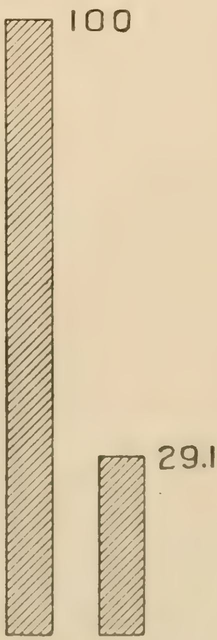
Summary.

Total number of reported cases of small-pox, ten years ending Dec 31, 1894,	357
Total number of deaths from small-pox in same period,	69
Ratio of deaths to cases (per cent.),	19.3
Of the foregoing there were among the vaccinated (cases),	145
Of the foregoing there were among the vaccinated (deaths),	8
Ratio of deaths to cases among the vaccinated (per cent.),	5.5
There were among the unvaccinated (cases),	165
There were among the unvaccinated (deaths),	48
Ratio of deaths to cases among the unvaccinated (per cent.),	29.1
There were among those in whom the facts relative to vaccination were doubtful or unknown (cases),	47
There were among those in whom the facts relative to vaccination were doubtful or unknown (deaths),	13
Ratio of deaths to cases among these (per cent.),	27.4

Fatality of the Vaccinated from Small-pox. Ratio of Deaths to Cases.



Fatality of the Unvaccinated from Small-pox. Ratio of Deaths to Cases.



The severe epidemic of 1872–73 is often quoted by the opponents of vaccination to disprove its efficacy ; but such statements, however, have no value, since they fail to show any definite information as to the comparative mortality from small-pox of the vaccinated and the unvaccinated. As a matter of fact, there are no statistics upon this point in Massachusetts for years prior to 1885. Hence the value of the foregoing tabular statement may be recognized, as confirming similar inquiries made in other countries. By this table it appears that the mortality from small-pox among the unvaccinated was 29.1 per cent., as compared with only 5.5 per cent. among the vaccinated, that of the former being more than five times that of the latter.

These 357 cases reported in the ten years ending with 1894 occurred in the following cities and towns : —

Boston,	138	Haverhill,	2
Holyoke,	40	Quincy,	2
Chicopee,	31	North Adams,	2
Worcester,	24	Brookline,	2
New Bedford,	17	Pepperell,	2
Lowell,	12	Great Barrington,	2
Springfield,	10	Lenox,	2
Westfield,	9	Milton,	2
Chelsea,	9	Methuen,	2
Huntington,	7	Dalton,	2
Fall River,	6	Holden,	2
State Almshouse,	4		

In the following cities and towns, one in each: Lawrence, Lynn, Waltham, Cambridge, Melrose, Stoneham, Natick, Randolph, West Springfield, Marlborough, Somerville, Spencer, Pittsfield, Northborough, Lanesborough, Russell, Chester, Belchertown, Attleborough, Granville, Blackstone, Maynard, Medway, Sherborn, Adams and Williamstown.

Thirteen of these cities and towns were places in which paper mills using rags are located; but the actual number of paper-mill operatives attacked with small-pox was only 19, or 5.4 per cent., a smaller ratio than that which prevailed in earlier epidemics. Several other persons were attacked who were doubtless indirectly exposed to infection from rags, being persons of other occupations living in the same families or tenements with paper-mill operatives. The outbreak in Chicopee in 1894 was traced to the neighboring paper-mill city of Holyoke.

Outbreaks involving one or more cases in each occurred in Boston in nine years out of the ten-year period; in Holyoke, in six

years; Springfield, four years; Lowell, three; Chelsea, three; Huntington, three; Worcester, two; Chicopee, two; Dalton, two; Quincy, two; New Bedford, two; Westfield, two; North Adams, two; and Pepperell, two. In two instances the occurrence of small-pox in two different years refers only to the prolongation of an outbreak from December of one year into the winter months of the following year.

The sexes of those cases which occurred in the first three years of this period were not stated. Of those cases in the remaining years wherein the sex was stated, 169 were males and 139 were females, or in the ratio of 129 males to each 100 females.

The nationality of reported cases was as follows, so far as the nationality was stated: —

United States,	118	France,	7
British Provinces,	86*	Germany,	4
Ireland,	53	Sweden,	3
Portugal,	12	Russia,	1
England,	10	Belgium,	1
Italy,	10	Finland,	1
Scotland,	9		

* Including French Canadians, 30.

The occupations of the persons attacked were as follows, so far as was stated in the returns: —

Operatives in paper mills,	19*	Seamen,	4
Operatives in other mills (not paper mills),	23†	Cigar makers,	4
Housewives,	28	Waiters,	4
Laborers,	21	Harness makers,	3
House servants,	13	Iron moulders,	3
School children,	13	Tramps,	3
Teamsters,	5	Painters,	2
Carpenters and cabinet makers,	6	Weavers,	2
Clerks,	4	Barbers,	2
Nurses,	4	Book-keepers,	2
Physicians,	3	Night watchman,	2
		Shoemakers,	2

Of the following occupations one each: farmer, milk pedler, baker, engineer, mechanic, draughtsman, yachtsman, morocco worker, nickel plater, stone cutter, bricklayer, plumber, butcher, bartender, telegraph operator, school teacher, rubber worker, machinist, expressman, fishmonger, whip maker, brass worker, bookbinder, salesman, errand boy, hostler, bootblack, corset maker, overseer of public institution.

* Females, 18; males, 1. † Females, 17; males, 6.

Small-pox by Ages, and with regard to Vaccination. — The following table embraces the statistics of the cases and deaths from small-pox by ages for the vaccinated and unvaccinated and for the cases and deaths in which the facts as to vaccination were unknown or doubtful. These relate only to those cases and deaths which occurred in the seven years 1888–94 : —

Small-pox. — Cases and Deaths in the Vaccinated and Unvaccinated, Massachusetts, 1888–94 (Seven Years).

Ages.	Vaccinated.		Unvaccinated.		Doubtful or Unknown.		Totals.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
0– 1 year, . . .	–	–	17	9	–	–	17	9
1– 5 years, . . .	4	–	36	6	–	–	40	6
5–10 years, . . .	1	–	17	–	–	–	18	0
10–15 years, . . .	13	–	6	–	2	–	21	0
15–20 years, . . .	17	1	18	4	6	2	41	7
20–30 years, . . .	51	3	33	10	12	4	88	17
30–40 years, . . .	16	3	15	5	1	1	32	9
40–50 years, . . .	16	1	3	2	3	–	22	3
Over 50 years, . .	9	–	–	–	3	1	12	1
Age unknown, . .	3	–	1	–	4	–	8	0
	130	8	146	36	31	8	307	42

The foregoing table contains much that is suggestive as to the efficiency of vaccination.

No vaccinated child under one year of age was attacked with small-pox, while there were 17 attacks of unvaccinated infants under one, and of these 9 died, or 53 per cent.

Among vaccinated persons under fifteen years of age there were 18 attacks and no deaths.

Among unvaccinated persons under fifteen years old there were 76 attacks and 15 deaths, or 19.7 per cent.

Among vaccinated adults, or persons over fifteen years old, there were 109 attacks and 8 deaths, or 7.3 per cent.

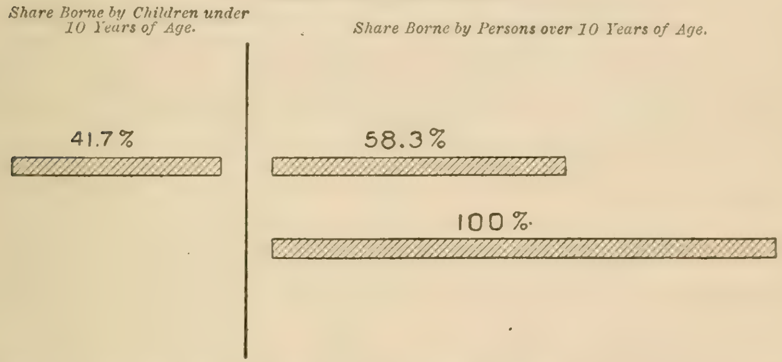
Among unvaccinated adults over fifteen years old there were 66 attacks and 21 deaths, or 31.8 per cent.

It is also worthy of note that 39 school children, or children of school ages (5–15) were attacked, and of this number 23 were unvaccinated. Out of this whole number (39), there were no deaths,

this being the period of life in which the specific intensity of life is greatest, *i. e.*, the power to resist fatal attacks of disease.

Out of the whole number of adults (109) who were recorded as having been vaccinated, 76, or nearly 70 per cent., were recorded as vaccinated in infancy only; and, judging from the carefully recorded statistics of the German government, it is safe to presume that the 8 deaths of vaccinated adults occurred among this class exclusively.

SMALL-POX MORTALITY.



The upper line of the diagram refers to the unvaccinated, and the lower line to the vaccinated class.

It is also worthy of note, as shown in the foregoing diagram, that all of the deaths of the vaccinated were among adults, while among the unvaccinated 15 deaths, or nearly 42 per cent. of the deaths of the unvaccinated, occurred among children under ten years of age. These facts show unmistakably the saving of child life through vaccination.

It is to be regretted that statistics relative to revaccination could not be included in the foregoing tables.

TYPHOID FEVER.

The mortality from typhoid fever in Massachusetts has diminished with a comparatively uniform rate during the past thirty years or more, and the rapidity of its diminution may be taken as an index of progress in the introduction of public water supplies throughout the State.

The old and once accepted theory of its intimate connection with periods of deficient rainfall and of consequent low water in wells and streams does not appear to be borne out by the experience of Massachusetts, since the disease has prevailed with about the same fre-

quency in years of deficient as well as of abundant rain, and some of the most severe epidemics have occurred in January and February, when the rainfall was abundant. The general tendency, however, in a succession of years has been in the direction of a decrease in its frequency.

The Board has been called to investigate a few limited epidemics during the year 1894, an account of one of which is presented in the present report, by Prof. W. T. Sedgwick, whose excellent papers in the report of 1892 upon the same subject are well known.

Haverhill. — The following statement relates to a limited outbreak of illness which occurred in a shoe factory in Haverhill, situated upon the bank of the Merrimack River, near the railroad bridge. Statements in regard to the matter first appeared in the newspapers, and about the same time a letter was received from a workman in the factory, who stated that he had been ill for several weeks, and attributed his illness to the water used for drinking at the factory in question. On inquiring at the factory it appeared that previous to Jan. 20, 1894, the water used there was that of the city supply. About this time (January 20) a supply of water was introduced to this factory direct from the river. Many of the operatives drank of this water, and a considerable number (25 or 30) were taken ill and remained ill for varying periods of time. At the time of the visit of the secretary, in March, one man then seen was convalescing from an attack of typhoid fever, who had been an operative in this factory, and was taken ill a few days after drinking the water.

Several physicians confirmed the statement as to the effect upon the operatives of drinking this water.

A public city sewer discharges its contents a short distance only above the point from which this water was taken.

The water had been introduced by the owners of the building without notifying either the tenants or the operatives as to its source or the danger of using it for drinking. The severe lesson which had been taught higher up in the same river at Lowell and Lawrence appears to have had no effect upon the owners of this property at Haverhill.

The State Board of Health, upon learning these facts, recommended the board of health of Haverhill "to put up a warning notice over each faucet where the water of the Merrimack River is provided, stating that the use of such water for drinking purposes is dangerous. The observations of the Board show that the use of

such water has in many instances been attended with serious illness and loss of life." The board of health of Haverhill complied with the advice of the State Board, and issued a regulation in conformity with its recommendation.

North Easton. — The Board was requested (Sept. 6, 1894) to investigate the circumstances of a limited outbreak of typhoid fever in North Easton. The secretary visited North Easton soon after the receipt of information from that town, and upon conference with the local board of health and physicians found that the number of cases was small. Some of these cases having occurred upon the route of a milkman, on visiting his dairy it appeared that he produced most of the milk which he sold in North Easton from a herd of twenty-two cows, and obtained the balance from a farmer who lived about a mile distant. Both of these dairies were in good condition, there had been no illness at either, and there was no reason to believe that the cases owed their origin to the milk supply.

Cambridge. — In the latter part of October it was reported by the board of health of Cambridge that several cases of typhoid fever had occurred on the route of a milkman who furnished a large number of customers. His depot or place from which the milk was issued was in West Somerville. The secretary visited this place Nov. 5, 1895. The milk dealer supplied three or four hundred families with about sixty cans of milk daily. The milk is collected by a collector from the towns of Bedford and Concord, Mass., and when received is put into a large tin mixer, capable of holding one hundred gallons or more. In continuance of this investigation, visits were made the same week to the different dairies in Bedford and Concord, which supplied the milk route in Somerville, and to the physicians in those towns. It did not appear that any illness had occurred upon the farms which regularly supplied milk to the Somerville milk dealer which could in any way account for the outbreak.

On further inquiry, it appeared that a small dairy near the Shady Hill Nursery, on the line of a branch of the Boston & Maine Railroad, occasionally furnished a few cans of milk in times of deficiency, which were supplied to the Somerville milkman. In the family of the owner of this small dairy there had been a case of "gastritis" in a young girl, not believed to be typhoid fever, and later other mild cases of illness in the same family, not requiring medical attendance. The date of this case of "gastritis" was September 13–23. The next house was occupied by a man and wife and nine boarders,

the latter being employed at the nursery. Out of this family of eleven persons nine had been ill with typhoid fever, their illness continuing from about August 20 till the last of October. The milk for the use of this family was supplied for most of this time by the small dairy adjoining the nursery. The connection of these cases with the milk supply referred to is not clear, but the nearness of the two houses and the visits of convalescing or ambulant cases from the boarding-house to the dairy in question, and possibly to the cow stables, would seem to afford at least a probable explanation of the contamination of the milk supply. The contractor was advised to cease taking milk from this source for a definite period.

For convenience of reference the table published on page xii of the twenty-third annual report of the Board is repeated herewith, with the addition of the figures for the three years 1891–93 : —

Deaths from Typhoid Fever in Cities of Massachusetts, 1871–93.

	Five Years. 1871-1875.	Five Years. 1876-1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	Total, Twenty-three Years.	Av'ge Annual Death Rate from Typhoid Fever, per 10,000 Living.
Boston,	1,145	690	212	223	167	202	148	142	180	174	176	146	152	137	136	4,030	4.54
Worcester,	176	131	21	28	18	20	19	19	30	25	21	14	16	17	30	585	3.90
Lowell,	221	117	54	50	49	41	49	50	90	62	69	125	78	77	55	1,187	8.23
Fall River,	176	152	32	51	33	26	32	30	45	46	48	40	49	27	18	805	6.21
Cambridge,	124	55	21	18	22	26	16	21	22	31	24	18	17	15	18	448	3.38
Lynn,	118	72	25	28	22	18	16	13	12	14	6	11	12	13	13	393	3.96
Lawrence,	190	122	49	31	28	19	17	23	47	48	55	60	55	50	39	833	9.19
Springfield,	214	86	27	22	28	18	22	12	17	26	19	14	16	39	17	577	6.87
New Bedford,	99	50	12	12	8	23	7	25	6	11	21	8	9	15	29	335	4.59
Somerville,	69	33	6	8	13	8	10	3	12	17	8	9	13	14	13	236	3.51
Holyoke,	157	77	39	58	21	23	18	17	17	21	23	27	25	16	10	549	9.39
Salem,	87	61	19	13	15	6	13	16	12	11	8	12	9	18	17	317	4.90
Chelsea,	86	36	9	5	5	10	8	4	6	6	11	8	9	10	6	219	3.96
Haverhill,	46	40	6	13	9	41	13	16	17	6	9	11	7	13	13	230	4.86
Brockton,	43	14	17	8	9	4	3	9	8	13	9	7	11	8	3	166	4.00
Taunton,	65	34	16	19	7	8	9	17	24	7	9	1	3	9	7	235	4.50
Newton,	20	25	6	5	1	11	8	6	8	12	13	5	7	4	4	135	3.04
Malden,	25	31	5	6	4	2	4	8	8	3	8	6	6	6	5	127	3.55
Fitchburg,	32	17	4	2	2	5	5	6	6	9	7	3	5	–	5	108	3.02
Gloucester,	51	34	7	7	10	7	7	7	4	9	2	3	3	3	5	159	3.35
Waltham,	13	8	5	3	3	6	3	5	5	2	1	4	3	5	2	68	2.15
Pittsfield,	56	29	7	10	5	10	2	8	10	9	5	8	5	6	5	175	5.30
Quincy,	19	21	2	8	3	8	6	1	12	12	6	6	5	7	11	127	4.55
Northampton,	46	19	8	2	7	10	2	6	3	6	5	2	2	3	6	127	4.32
Chicopee,	63	35	11	3	15	10	9	4	10	11	6	12	9	24	10	232	8.55
Newburyport,	29	31	7	6	2	3	4	1	3	2	5	6	5	3	7	114	3.64
Marlborough,	27	20	4	4	4	4	4	9	6	5	7	5	4	3	7	113	4.54
Woburn,	26	10	1	7	2	2	2	4	2	7	7	4	7	8	4	93	3.54
Medford,	11	12	5	1	2	–	3	3	3	2	2	1	3	2	6	56	2.84
Everett,	6	2	1	3	2	1	2	1	6	5	1	1	4	1	4	40	2.82
Beverly,	18	13	2	6	1	–	1	6	1	1	–	2	2	3	1	57	2.77
	3,458	2,077	640	660	517	542	462	492	632	613	591	579	551	556	506	12,876	4.90

Offensive Trades.

During 1894 two petitions were received requesting the consideration of the Board under the provisions of the offensive trade Acts.

The two establishments referred to in these petitions were located in the city of Woburn. The first was the establishment of the Butchers' Rendering Association, located near the eastern boundary of Woburn, and a few rods south of Cedar Street. The complainants were residents of Woburn and Stoneham, most of whom lived within a half-mile of the works. The establishment consisted of one wooden building, containing the usual apparatus for rendering the refuse products of meat markets, which were collected in the neighboring towns and were brought to the works for disposal. The processes conducted in the building were those of rendering bones and grease, the making of tallow, the drying of the refuse for conversion into fertilizers, and the burning of clay or marl. The liquid matter from the rendering tanks was conducted through an iron pipe to some trenches made in a gravel bed a few rods north of the works.

The principal exhalations of foul odor appeared to arise from the discharge of the contents of the tanks when they were daily opened, from the drying of the refuse and from the decomposition of the liquid in the trenches. The trenches were covered with gravel to a depth of two or three feet, but the foul odor came up through the gravel and was conveyed by the winds toward the neighboring houses. This appeared to be the source of the most offensive odor.

In compliance with the provisions of the statutes (chapter 80, section 93, Public Statutes), a hearing was given by the Board at its office on June 7, 1894, at which the petitioners and the association were represented by counsel and several witnesses.

As a result of this hearing, it was *Voted*, "That the Butchers' Rendering Association be advised to modify and improve its present methods of operation at its works in Woburn, and that further consideration of the matter of the petitioners be continued until the first Thursday of July next."

Upon receipt of this communication the association took measures to improve its methods of work. The interior of the building was put in more cleanly condition, and apparatus was purchased for the more satisfactory treatment of the material. The use of sulphuric acid in the trenches outside the building was abandoned, and

chloride of lime was substituted. A larger and deeper trench was dug and covered, and the liquor was conducted into it. The foul odor from this trench was now evidently the chief source of annoyance, and, although it was not so serious as it had been when the smaller trench was used, an extremely offensive stench still continued to arise through the gravel.

About this time, Oct. 1, 1894, the works were destroyed by fire, and all operations and consequently all further nuisance ceased at this establishment.

In November, 1894, a petition was received from the board of health, selectmen and one hundred and fifty citizens of Reading, requesting that the nuisance caused by the Pantasote works at North Woburn should be abated. Complaint had already been made to the board of health of the city of Woburn in March, 1893, to the same effect, and a temporary cessation of operation at these works followed for nearly a year and a half.

The establishment is located in the north-east part of Woburn, near Wilmington and Reading, west of the Boston & Maine Railroad, Lowell division, and quite near the Merrimac Chemical Works. The process conducted here was the boiling of linseed oil at a high temperature (500° F. or more). An extremely pungent and offensive odor was given off, which was even more offensive at a distance than it was in the immediate neighborhood of the works. This process is distinctly recognized as an offensive trade in Ballard's effluvium nuisances, and is subject to strict regulations in England.

All of the complainants lived in Reading, at a distance of between one and two miles from the works, while the odor had been distinctly recognized in other towns at a distance of four miles and more when the wind favored.

On Nov. 20, 1894, the secretary visited the establishment, in company with the board of health of Woburn, and while the work was in operation. As a result of this visit, and in compliance with the petition, a hearing was appointed for Dec. 1, 1894; but before the date of the hearing the board of health of Woburn issued an order prohibiting the further exercise of the business, and the annoyance ceased.

Green Harbor River.

A petition was received in September from citizens of Marshfield living at Green Harbor River upon the sea-shore in that town, having reference to certain conditions existing at that place since the

construction of a dike, which was built across the river or estuary about twenty years since. This dike was built under the provisions of chapter 303 of the Acts of 1871, and had for its object the reclaiming of a tract of salt marsh, having an area of two or three square miles. The desired object was accomplished, this tract being transformed into a fresh-water region. As a result, however, the harbor below the dike has become very much shallower than before, and above the dike in the various creeks and inlets an abundant growth of algæ in summer produces an offence to the eye and to the sense of smell. It was to this latter condition that attention was particularly directed in the petition.

It did not appear, upon examination, that the health of the neighboring population had been affected by the existing condition of the marshes and creeks above the dike, nor that this condition was likely to prove harmful in the future. For the other condition — the silting of the harbor below the dike — an adequate remedy is provided in the statute which authorized its construction.

Impure Ice.

In 1886, the following statute was enacted, having for its object the prevention of the sale of impure ice: —

[Acts of 1886, Chapter 287, Section 1.]

Upon complaint in writing of not less than twenty-five consumers of ice which is cut, sold and held for sale from any pond or stream in this Commonwealth, alleging that said ice is impure and injurious to health, the state board of health may appoint a time and place for hearing parties to be affected and give due notice thereof to such parties, and after such hearing said board may make such orders concerning the sale of said ice as in its judgment the public health requires.

The two remaining sections of the law provided for an injunction to enforce such orders and for the right of appeal to a jury.

In August, 1894, a petition was received from summer residents at Clifton in Marblehead, having the required number of signatures, asking the Board to investigate the ice supply of that place, which was procured from Ware's Pond, a small body of water in Marblehead near Swampscott. A death had occurred at Clifton from typhoid fever among the persons using this ice, and attention had been attracted to this pond as a possible source of illness. An investiga-

tion of the pond and its surroundings, and an analysis of the water and ice were made by the Board.

The pond is a small one, having an area of about four or five acres. It is shallow, and the bottom is muddy. It is near the railroad track, and a few rods from the sea-shore. A short distance to the west is another pond of smaller size and similar character. The immediate borders of these ponds consist of meadow land, and on the south side there is a small wooded swamp. On the immediate watershed of these ponds are not more than a half-dozen houses, none of which drain directly to the ponds. There is also one large stable north of Ware's Pond.

The ice supply was exhausted in August, and the local dealer was obliged to go to New Hampshire for an additional supply; hence at the time of the investigation in the autumn no ice remained for examination. A sample of water was then taken for analysis, and as soon as the ice had acquired a thickness sufficient for cutting (twelve inches), a sample of ice was taken (Jan. 15, 1895). The following is the result of the analysis of the water and ice: —

[Parts per 100,000.]

Number.	Appearance.			Odor.	
	Turbidity.	Sediment.	Color.	Cold.	Hot.
13151	Distinct.	Slight.	0.53	Decidedly mouldy, unpleasant.	Decidedly mouldy, unpleasant.
13665	V. slight.	Cons., dark.	0.00	None.	None.
13666	None.	V. slight.	0.00	None.	None.

[Parts per 100,000.]

Number.	Residue on Evaporation.			Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
	Total.	Loss on Ignition	Fixed.	Free.	Albuminoid		Nitrates.	Nitrites.			
13151	9.35	3.35	6.00	.0528	.0468	1.59	.0000	.0008	.7979	3.1	.0100 / .0085
13665	-	-	-	.0026	.0116	.10	.0030	.0000	.1540	-	-
13666	-	-	-	.0014	.0014	.02	.0030	.0000	.0118	-	-

No. 13151. Pond. Sample of water collected Oct. 16, 1894.
No. 13665. Top of cake snow ice. Sample of ice collected Jan. 15, 1895.
No. 13666. Bottom of cake clear ice. Sample of ice collected Jan. 15, 1895.
The unusual ratio of chlorine in this sample is readily accounted for by the proximity of this pond to the sea-shore.

As a result of this investigation and analysis, the Board found no reason to believe that the ice of Ware's Pond had proved injurious to health. It was, however, required that the local dealer should follow certain directions to insure a crop of ice of good quality; namely, that the pond should not be flooded over existing ice, for the purpose of obtaining thicker ice, and that the upper two inches of ice should be shaved off and rejected.

Notification of Infectious Diseases.

The laws relating to the notification of infectious diseases have been revised from year to year, and are now in a more efficient form than ever before.

The early laws requiring notice to be given by householders and physicians in cases of small-pox or other diseases dangerous to the public health were amended in 1884 by specifying also diphtheria and scarlet-fever.

A further amendment required the disinfection of rooms occupied and articles used by the sick.

A later amendment required the physician to give notice in writing over his own signature.

The Statutes of 1884, chapter 98, also required boards of health to keep records of cases of infectious diseases, and to give notice of such cases to the school committees. It also required the Secretary of State to furnish the blank record books for recording such cases of illness.

By the Statutes of 1893 it was still further required that the local boards of health should notify the State Board of the occurrence of all cases of diseases dangerous to the public health which had within twenty-four hours been reported to such local boards of health. This law of 1893 has therefore been in operation a year and a half, and affords a useful method of obtaining frequent information as to the prevalence of infectious diseases throughout the State. Definite information as to the operation of this law may be found under the title of Infectious Disease Notification in the following pages.

Trichinosis.

Since the occurrence of the two outbreaks of trichinosis which occurred in Colerain and in Boston in the winter of 1892, comprising about fifty cases and five deaths, no further cases have been reported in the State. The Board has, however, continued its inves-

tigations as to the causes of the disease, which were made the subject of a report by Prof. E. L. Mark of Cambridge in the twentieth annual report of the Board (p. 713). These additional investigations have been conducted at one of the State institutions, and present valuable information relative to the effects of careful methods of feeding in reducing the extent of trichinosis in swine. It is proposed to repeat the same series of experiments at another State institution.

THE

VITAL STATISTICS OF MASSACHUSETTS

FOR 1893.

THE VITAL STATISTICS OF MASSACHUSETTS FOR 1893.

BY THE SECRETARY OF THE BOARD.

Among the duties which were proposed and carefully defined by the Massachusetts Sanitary Commission of 1850 as properly belonging to a general or State board of health, special prominence was given to that of supervising the vital statistics of the State.

The intimate connection between the vital statistics of a State or nation and its public health must be everywhere acknowledged, since the former constitutes the only accurate measure of the efficiency with which public health measures have been administered. An annually increasing demand made upon the Board for information relative to the vital statistics of the State makes it necessary to supply this information through the annual reports of the Board.

Dr. Billings, the highest American authority upon the subject, says: "My observation of the progress of public health work in this and in other countries for the past twenty years leads me to believe that this progress, in any locality, for any considerable length of time, depends on the completeness of its vital statistics, and the use that is made of them" ("Transactions of American Public Health Association," Vol. 15, 1880, page 43).

In the introduction of improved methods in the presentation of the following summary it has been the aim of the compiler to secure clearness and simplicity in the methods adopted, and to bring them into line with those of other countries, in order that comparison may thereby be more readily made. The compiler acknowledges his indebtedness to M. Körösi of Budapesth for valuable advice. To him the world owes much for his earnest efforts in securing international uniformity in the method of presentation of statistics.

New Features in the Following Summary.

Beginning with 1855, a table appears in the registration reports of Massachusetts which presents the numbers of persons dying in each year from certain diseases, by sexes, months of the year and

ages of life. Other tables are appended in the reports of the following years in which the same facts are presented for a group of years. The percentages of deaths in each sex were also given, the percentages of deaths in each month, and also those of each age period, as compared with the total mortality. The fallacy of employing the total mortality as the only standard of comparison has been so frequently pointed out * that it was deemed best in 1887 to introduce a new table, in which the deaths at each age of life are compared with the living population of the same age.

These important and valuable tables are now reproduced in this Summary, and have been still further improved by the comparison of the deaths by sexes in the same manner with the living population of each sex. The effect of the inequalities in the lengths of the months is eliminated by adopting a standard of equal lengths of time in each month, and of reducing the numbers of deaths in such uniform divisions of time to a standard of 100, which answers the purpose, since the object in such a seasonal table is not to determine the absolute number of deaths from a given cause in each month, but the relative intensity of a given disease or cause of death as shown by the mortality in these different portions of the year.

The difference in the two methods becomes most apparent so far as seasonal prevalence is concerned in the case of a disease which, like consumption, shows a comparatively uniform mortality throughout the year.

The same method has been employed in treating the monthly distribution of marriages, births and deaths, and is nearly identical with that which is employed by Dr. R. Böckh, director of the statistical office of the city of Berlin, in his comprehensive year book.

It is deemed advisable to omit altogether from the discussion of diseases the comparison with the total mortality, and to give only the ratio to the living population, except in Table 24, relating to the statistics of certain causes of death (1874–93).

Comparison with the living population can be made with comparative accuracy in Massachusetts in consequence of the fact that

* See papers of Dr. W. E. Smith on consumption and pneumonia in Massachusetts, in "Transactions of Massachusetts Medical Society," 1887; and by Dr. E. Farnham on consumption in Cambridge, in "Transactions of Massachusetts Association of Boards of Health," Vol. IV., 1894.

a census is here made every five years, either by the State or national government, and within the limits of a five-year period it is not difficult to estimate the population of each year with a fair degree of accuracy. The annual rate of growth for a century has never been less than one per cent., except in the war period 1860–65, when it was about one-half of one per cent., and but once was it above three per cent. (in the period 1840–50).

Another feature of importance is the table of vital statistics of cities and towns having over 10,000 inhabitants, which embraces the period of three years, 1891–93. The fact that the urban population (cities and towns over 10,000) had grown from a percentage of less than one-fourth of the total population in 1840 to more than 65 per cent. in 1890 sufficiently explains the importance of this table. A portion of the statistical tables for counties is presented; but the rapidly increasing prominence of the urban population makes it essential to devote a greater amount of space to the municipalities having over 10,000 population in each.

Recent discussions upon infant mortality have also made it desirable to present this important portion of the subject with more than ordinary fulness of detail; the death rates of children from all causes and from several of the diseases of childhood are for the first time presented for each separate year of life up to five years.

The legislative discussions upon tuberculosis have induced us to introduce a comparatively greater number of carefully prepared statistics in regard to this disease.

General Summary.

The number of registered marriages in 1893 was 22,814, the births were 67,192 and the deaths were 49,084. The still-births numbered 2,444.

The ratios to the estimated living population were as follows: —

	Per 1,000.
Marriage rate,	9.36
Persons married,	18.71
Birth rate,	27.55
Death rate,	20.13
Excess of birth rate over death rate,	7.42

International Vital Statistics.

In Table 1 are presented the marriage, birth and death rates of the New England States and those of the principal countries of Europe having registration for a period of twenty years (1871–90) and for the years 1892 and 1893.

The six New England States had in 1890 a population of 4,700,745, the estimate for 1893 being a little more than 5,000,000, and all the countries embraced in this summary had about 265,000,000 at the latest census.

The estimates of population upon which the ratios for each country are based are made by the authorities having in charge the registration of these countries. Those of the New England States are based upon the census of 1890, and the rate of growth in the preceding intercensal period.

Population.

"Population, as the natural basis of all vital statistics, necessarily demands preliminary consideration in any work dealing with that subject." — Dr. Farr.

The population of Massachusetts in 1890, as enumerated by the United States census officials, was 2,238,943.

Sex. — Of this number, 1,087,709 were males and 1,151,234 were females.

Age. — Table 2 presents the figures of six census enumerations of the State by age periods, with the percentages at each age period. The total numbers of each sex are also given, with the percentages of each. The table shows that the percentages of males and females were more nearly alike at the census of 1890 than at either of the preceding census enumerations, being in the ratio of 1,000 males to 1,058 females, as compared with 1,000 males to 1,076 females as the mean of the six census enumerations. The percentages of persons living at the two age periods under five, and five to nine, had diminished, while those of the age periods above twenty years had increased, — a fact which is probably not due to a diminishing birth rate, but to an increased accession by immigration

at the later age periods. The birth rates have slightly increased from 1880 to 1890.

In this table the census figures are presented without correction or adjustment.

The population of the counties in 1890 was as follows: —

Barnstable,	29,172	Hampshire,	51,859
Berkshire,	81,108	Middlesex,	431,167
Bristol,	186,465	Nantucket,	3,268
Dukes,	4,369	Norfolk,	118,950
Essex,	299,995	Plymouth,	92,700
Franklin,	38,610	Suffolk,	484,780
Hampden,	135,713	Worcester,	280,787
THE STATE,			2,238,943

TABLE 1. — *Summary of the Vital Statistics of Principal Countries for Twenty Years, and for 1892 and 1893, together with those of the New England States.*

STATES AND COUNTRIES.	TWENTY YEARS — 1871-1890.				1892.				1893.			
	Marriage Rate.	Birth Rate.	Death Rate	Excess of Birth Rate over Death Rate.	Marriage Rate.	Birth Rate.	Death Rate.	Excess of Birth Rate over Death Rate.	Marriage Rate.	Birth Rate.	Death Rate	Excess of Birth Rate over Death Rate.
Massachusetts,	18.1	25.7	19.7	6.0	19.0	27.8	20.6	7.2	18.7	27.5	20.1	7.4
Maine,	-	-	-	-	17.3	20.7	18.4	2.3	-	-	-	-
New Hampshire,	18.6	18.0*	18.9	-	21.3	19.1*	20.1	-	-	-	-	-
Vermont,	15.6	20.2	15.1	5.1	17.5	19.7	17.9	1.8	-	-	-	-
Rhode Island,	18.7	23.7	18.0	5.7	19.3	24.5	20.4	4.1	19.0	25.8	20.0	5.8
Connecticut,	16.0	23.6	17.1	6.5	17.0	24.5	19.6	4.9	16.4	24.7	18.9	5.8
ALL NEW ENGLAND,	-	-	-	-	18.5	24.9	19.9	5.0	-	-	-	-
England and Wales,	15.6	34.0	20.3	13.7	15.4	30.5	19.0	11.5	14.7	30.8	19.2	11.6
Scotland,	13.9	33.6	20.4	13.2	14.1	30.7	18.5	12.2	13.2	31.0	19.4	11.6
Ireland,	9.0	24.9	18.0	6.9	9.3	22.4	19.4	3.0	9.4	23.0	17.9	5.1
Italy,	15.6	37.3	28.6	8.7	15.0	36.3	26.2	10.1	14.7	36.6	25.3	11.3
Denmark,	15.2	31.7	19.0	12.7	13.6	29.5	19.4	10.1	14.1	30.6	18.9	11.7
Norway,	13.7	30.7	16.9	13.8	12.6	29.6	17.7	11.9	12.8	30.7	16.4	14.3
Sweden,	13.1	29.8	17.6	12.2	11.4	27.0	17.9	9.1	-	-	-	-
Austria,	16.3	38.6	30.6	8.0	15.6	36.2	28.8	7.4	-	-	-	-
Hungary,†	19.1	44.0	33.7	10.3	18.4	40.3	35.0	5.3	18.6	42.5	31.1	11.4
Switzerland,	14.7	29.4	22.1	7.3	14.7	28.0	19.3	8.7	14.7	28.5	20.5	8.0
German Empire,‡	16.4	38.1	26.0	12.1	15.9	35.7	24.1	11.6	15.8	36.7	24.6	12.1
Holland,	15.1	35.2	22.6	12.6	14.4	32.0	21.0	11.0	14.6	33.8	19.2	14.6
Belgium,	14.2	31.0	21.4	9.6	15.4	28.9	21.8	7.1	15.2	29.5	20.3	9.2
France,	15.4	24.6	22.8	1.8	15.2	22.1	22.6	—0.5§	-	-	-	-
Japan,‖	-	27.2	19.9	7.3	-	-	-	-	-	-	-	-

* Seven years. Registration of births said to be defective. † Fifteen years. ‡ Nineteen years. § Excess of death rate. ‖ Ten years (1881-90.)

TABLE 2. — *Massachusetts. — Population by Sex and by Age Periods. — State and National Census (1865–90).*

Years.	Totals.	Males.	Females.	Under 5.	5-9 inclusive.	10-14 inclusive.	15-19 inclusive.	20-29 inclusive.	30-39 inclusive.	40-49 inclusive.	50-59 inclusive.	60-69 inclusive.	70-79 inclusive.	80 and over	Unknown Age.
1865, . .	1,267,031	602,010	665,021	133,943	143,391	126,691	117,171	225,506	185,543	142,831	96,446	59,216	26,675	8,316	1,302
1870, . .	1,457,351	703,779	753,572	156,889	139,796	148,371	142,184	274,859	214,151	162,689	108,348	68,401	31,895	9,727	41
1875, . .	1,651,912	794,383	857,529	173,855	163,738	148,365	165,936	310,861	240,966	182,823	126,430	79,186	38,283	11,167	10,302
1880, . .	1,783,085	858,440	924,645	179,307	171,595	161,425	167,595	343,701	264,413	203,515	142,053	91,619	44,337	13,525	-
1885, . .	1,942,141	932,884	1,009,257	178,338	181,842	176,551	187,247	384,750	287,219	222,920	156,760	101,619	49,235	15,516	144
1890, . .	2,238,943	1,087,709	1,151,234	203,758	195,578	192,228	214,613	465,387	341,622	253,181	178,131	114,172	55,886	17,886	6,501
Mean, .	1,723,410	829,867	893,543	171,015	165,990	158,939	165,791	334,177	255,652	194,660	134,695	85,702	41,052	12,689	3,048
PERCENTAGES. 1865, .	100.00	47.52	52.48	10.57	11.32	9.99	9.25	17.80	14.64	11.27	7.61	4.67	2.11	.66	.10
1870, .	100.00	48.29	51.71	10.77	9.59	10.18	9.76	18.86	14.70	11.16	7.43	4.69	2.19	.67	-
1875, .	100.00	48.09	51.91	10.53	9.91	8.98	10.04	18.82	14.69	11.07	7.65	4.79	2.32	.68	.62
1880, .	100.00	48.15	51.85	10.06	9.62	9.05	9.40	19.28	14.83	11.41	7.97	5.14	2.49	.76	-
1885, .	100.00	48.03	51.97	9.18	9.36	9.09	9.64	19.81	14.79	11.48	8.07	5.23	2.54	.80	.01
1890, .	100.00	48.58	51.42	9.10	8.73	8.59	9.59	20.78	15.26	11.31	7.95	5.10	2.50	.80	.29
Mean,	100.00	48.15	51.85	9.92	9.63	9.22	9.63	19.39	14.83	11.29	7.82	4.97	2.38	.74	.18

In the section of this summary which treats of deaths, the figures for the first five years of life for the census of 1890 have been redistributed or adjusted, in order to estimate the death rates at each separate year of life up to five years from all causes, and for certain of the destructive diseases of childhood with greater accuracy. For this purpose the general principles laid down in Mr. E. B. Elliott's article in the second volume of the ninth census have been employed. (See further discussion of this subject under the title of Deaths by Ages.)

The estimate of the population of Massachusetts for 1893, upon which the marriage, birth and death rates in this summary are calculated, is 2,438,362.

Marriages.

The whole number of marriages registered in Massachusetts in 1893 was 22,814, which was a greater number than was registered in any previous year. This number indicated a marriage rate of 18.71 per thousand of the estimated population (persons married), and 9.35 marriages per 1,000.

The marriages and marriage rates for the ten years 1884–93 were as follows: —

Table 3. — *Marriages and Marriage Rates, 1884-93.*

YEARS.	Marriages.	Marriage Rates.
1884,	17,333	18.2
1885,	17,052	17.6
1886,	18,018	18.0
1887,	19,533	19.0
1888,	19,739	18.7
1889,	20,397	18.7
1890,	20,838	18.6
1891,	21,675	18.8
1892,	22,507	20.0
1893,	22,814	18.7
Total,	199,906	–
Mean,	–	18.6

The marriage rate has declined during the period of registration, the highest marriage rate being that of 1854, when it was 24.8 per 1,000; and the minimum was in 1878, when it was 14.9. The mean rate for the five-year period 1851–55 was 23.2, and that of the five-year period 1876–80 was 15.7.

In the past ten years or more it has remained fairly uniform, the rate for the five-year period 1881–85 being 18.5, and that of 1886–90 being 18.6. For the three years 1891–93 it was 18.9.

The marriage rate of England has declined slightly, from a maximum of 17.9 in 1853 to a minimum of 14.2 in 1886, and a slight increase to 15.6 in 1891. Those of Denmark, Sweden and Hungary have declined slightly, while those of Prussia, Italy and France have remained nearly stationary.

Marriages by Counties. — The number of marriages in each county during the three years 1891, 1892, 1893, together with the marriage rates for 1890, was as follows: —

TABLE 4. — *Marriages by Counties, 1891-93, and Marriage Rates, 1890.*

	1891.	1892.	1893.	Marriage Rates, 1890.
THE STATE,	21,675	22,507	22,814	18.62
Barnstable,	245	221	209	16.78
Berkshire,	605	625	613	15.12
Bristol,	1,850	2,045	2,089	20.22
Dukes,	33	38	39	18.54
Essex,	2,905	2,899	3,108	18.48
Franklin,	310	331	335	14.76
Hampden,	1,388	1,479	1,401	17.64
Hampshire,	448	438	410	16.26
Middlesex,	4,083	4,259	4,373	17.80
Nantucket,	16	28	21	11.00
Norfolk,	944	956	976	15.76
Plymouth,	798	804	840	17.32
Suffolk,	5,574	5,708	5,745	21.94
Worcester,	2,476	2,676	2,655	17.70

NOTE. — Marriages and marriage rates of the urban population may be found on a later page.

Age. — The average ages at marriage of all men and women married, and of men and women married for the first time, were as follows: —

TABLE 5.—*Average Ages at Marriage, 1891-93, expressed in Years and Fractions of a Year.*

	Average Age of All Bridegrooms.	Average Age of All Brides.	Average Age of Men* Marrying for the First Time.	Average Age of Women Marrying for the First Time.
1891, ...	28.85	25.53	26.82	24.28
1892, ...	28.85	25.37	26.76	24.24
1893, ...	28.90	25.47	26.86	24.40

Four hundred and forty-one men and 3,628 women married when under twenty years of age, and 64 men and 5 women married when over seventy. Of the former class there were 46 women aged fifteen, 10 aged fourteen and 1 of thirteen years; all the men were over fifteen years of age.

Seasons.—The marriages by calendar months were as follows for 1893:—

TABLE 6.—*Marriages by Months (1893).*

	Marriages.	Monthly Ratio compared with a Standard of 100.*		Marriages.	Monthly Ratio compared with a Standard of 100.*
January, . .	1,999	103.2	September, .	1,953	104.2
February, . .	1,592	91.0	October, . .	2,319	119.8
March, . .	1,000	51.6	November, .	2,414	128.8
April, . .	2,396	127.9	December, .	1,413	73.0
May, . . .	1,636	84.5	Unknown, .	14	–
June, . . .	2,830	151.0			
July, . . .	1,570	81.1	Total, . .	22,814	–
August, . .	1,678	86.7	Mean, . .	–	100.0

* In this column the inaccuracies due to the unequal lengths of the months are eliminated by finding the daily number of marriages in each month and comparing this number with a daily standard of 100 for the whole year.

The mean daily number of marriages for the year was 62.5.

BIRTHS.

The whole number of living births registered in Massachusetts in 1893 was 67,192, which was larger than that of any previous year since the beginning of registration. The birth rate was 27.6 per 1,000 of the estimated living population, which was larger than that of any year since 1874 except that of 1892, which was 27.8.

The births and birth rates for the ten years 1884–93 were as follows:—

TABLE 7. — *Births and Birth Rates, Ten Years, 1884-93.*

Years.	Births.	Birth Rates.	Years.	Births.	Birth Rates.
1884, . .	48,615	25.5	1891, . .	63,004	27.4
1885, . .	48,790	25.1	1892, . .	65,824	27.8
1886, . .	50,788	25.4	1893, . .	67,192	27.6
1887, . .	53,174	25.9			
1888, . .	54,893	25.9	Total, .	567,132	-
1889, . .	57,075	20.2			
1890, . .	57,777	25.8	Mean, .	-	26.3

Sex. — Of the whole number of living children born in 1893, 34,328 were males and 32,829 were females, indicating a ratio of 1,046 males to 1,000 females, that of the period of forty-one years (1853–93) having been 1,055 males to 1,000 females.

The following were the numbers by sexes for the three years 1891–93 : —

TABLE 8. — *Births by Sexes, 1891, 1892 and 1893.*

Years.	Males.	Females.	Males to 1,000 Females.
1891, ...	32,532	30,434	1,069
1892, ...	33,758	31,951	1,057
1893, ...	34,328	32,829	1,046

The ratio of male to female births in England for the fifty-six years ending with 1893 was 1,043 males to 1,000 females.

Seasons. — The number of births in each month and the monthly ratio reduced to a standard of 100 was as follows : —

TABLE 9. — *Births by Months (1893).*

Months.	Births.	Monthly Ratio reduced to a Standard of 100.	Months.	Births.	Monthly Ratio reduced to a Standard of 100.
January, . .	5,611	98.3	October, . .	5,716	100.2
February, .	5,107	99.1	November, .	5,519	99.9
March, . .	5,549	97.2	December, .	5,767	101.0
April, . .	5,391	97.6			
May, . .	5,163	90.4	Unknown, .	6	-
June, . .	5,457	98.8			
July, . .	6,095	106.8	Total, .	67,192	-
August, . .	6,173	108.1			
September, .	5,638	102.1	Mean, .	-	100.0

The mean daily number of births was 184.1, and from the foregoing table it appears that the highest daily number of births occurred in August, July and September, and the least in May, March and April.

The highest quarterly percentage of births registered was in the third quarter of the year, and the same may be said of the births in each year of the previous twenty-year period, except 1873 and 1878, in which the greatest number was in the fourth quarter.

Births by Counties. — The numbers of living births in each county during the three years 1891, 1892 and 1893, together with the birth rates for 1890, were as follows: —

TABLE 10. — *Births by Counties, 1891–93, and Birth Rates, 1890.*

	1891.	1892.	1893.	Birth Rates, 1890.
THE STATE, ...	63,004	65,824	67,192	25.81
Barnstable, ...	530	546	516	16.38
Berkshire, ...	2,179	2,083	2,283	26.32
Bristol, ...	5,436	5,924	6,200	26.58
Dukes, ...	56	71	73	18.08
Essex, ...	7,804	7,784	8,392	23.68
Franklin, ...	813	898	908	19.68
Hampden, ...	4,611	4,708	4,864	30.47
Hampshire, ...	1,126	1,229	1,194	20.90
Middlesex, ...	12,347	12,879	13,197	25.85
Nantucket, ...	52	50	55	15.30
Norfolk, ...	2,947	2,956	3,132	22.78
Plymouth, ...	1,905	1,946	2,144	18.96
Suffolk, ...	15,227	16,542	15,538	28.98
Worcester, ...	7,971	8,208	8,696	26.07

NOTE — Births and birth rates of the urban population may be found on a later page.

Illegitimacy. — The number of illegitimate births registered in 1893 was 540. The statistics of the years 1891, 1892 and 1893, with the ratios per 1,000 of living births, are as follows: —

TABLE 11. — *Illegitimate Births.*

YEARS.		Ratio per 1,000 Births.
1891, ...	1,078	17.1
1892, ...	990	15.0
1893, ...	540	8.0

The mean ratio for the ten years 1884–93 was 17.47 per 1,000 births.

TABLE 12. — *Illegitimate Births by Counties (1891, 1892 and 1893).*

	The State.	Barnstable.	Berkshire.	Bristol.	Dukes.	Essex.	Franklin.	Hampden.	Hampshire.	Middlesex.	Nantucket.	Norfolk.	Plymouth.	Suffolk.	Worcester.
1891, .	1,078	11	21	50	–	79	5	44	7	121	1	22	14	654	49
1892, .	990	8	27	65	3	81	10	62	12	171	3	21	13	445	69
1893, .	540	10	26	59	1	94	10	46	8	149	2	23	11	14	87

In the foregoing table are presented the statistics of illegitimate births by counties for the three years ending with 1893. The special point worthy of note in this table is the apparently defective record of Suffolk County for the year 1893.

The following are illegitimate birth rates for several countries for the five-year period 1878–82, and for the year 1889 (*Bertillon*).

TABLE 13.

Countries.	Illegitimate Births per 1,000 Births.* 1878-82.	Illegitimate Births per 1,000 Births.* 1889.	Illegitimate Births to Each 10,000 Unmarried Women over Fifteen Years of Age.
Ireland, ...	25	28	31
Russia, ...	28	27	–
Holland, ...	30	33	66
Switzerland, ...	47	47	74
England and Wales, ...	48	46	103
Italy, ...	73	73	169
France, ...	74	84	109
Belgium, ...	77	88	139
Norway, ...	82	74	146
Scotland, ...	84	79	151
German Empire, ...	89	–	206
Denmark, ...	101	93	203
Sweden, ...	101	101	158
Saxony, ...	127	125	343
Bavaria, ...	132	141	295
Austria, ...	143	147	330

* Still-births are excluded in the column for 1889, in estimating the ratio in all the countries except Switzerland and Bavaria.

Plural Births. — In 1893 there were registered 619 cases of plural births, being in the ratio of 9.1 per 1,000 births. The number of children born was 1,247, of which number 1,220 were twins and 27 were triplets. Of the whole number, 627 were males and 618 were females.

The statistics for the three years 1891, 1892 and 1893 were as follows : —

TABLE 14.

YEARS.	Cases of Twins.	Cases of Triplets.	Cases of Quad-ruplets.	Numbers of Living Births to one Case of Twins.	Number of Living Births to one Case of Triplets.
1891,	616	7	1	102	9,000
1892,	572	8	–	115	8,228
1893,	610	9	–	110	7,466
Total 3 years,	1,798	24	1	–	–
Mean,	–	–	–	109	8,168
Total cases 1874–93,	8,847	99	–	–	–
Mean,	–	–	–	114	10,148

There has been a notable increase in the number and ratio of cases of triplet births in the past six years, from 1 in 27,446 in 1888 to 1 in 7,466 in 1893.

Still-births. — The total number of still-births registered in 1893 was 2,444, the numbers for the two preceding years being 2,222 in 1892 and 2,293 in 1891.

The following are the statistics relative to the sexes of the still-born for 1893 and for the period 1853 to 1893, forty-one years : —

	1893.	1853-93.
Total number of the still-born,	2,444	53,435
Males,	1,420	29,517
Females,	921	19,914
Not stated,	103	4,004
Ratio of males to 1,000 females, among those whose sex was known,	1,542	1,482

DEATHS.

"Mortality statistics surpass all other vital statistics in importance, whether they are considered from a social, an actuarial or a sanitary standpoint." — NEWSHOLME.

The number of deaths registered in 1893 was 49,084; this was greater than that of any previous year of registration.

The death rate per 1,000 of the estimated living population was 20.13, that of the decade ending with 1893 having been 19.66.

The following are the deaths and death rates for the ten-year period 1884–93 : —

TABLE 15.

Years.	Deaths.	Death Rates.	Years.	Deaths.	Death Rates.
1884, . .	36,990	19.4	1890, . .	43,528	19.4
1885, . .	38,094	19.6	1891, . .	45,185	19.6
1886, . .	37,244	18.6	1892, . .	48,762	20.6
1887, . .	40,763	19.8	1893, . .	49,084	20.1
1888, . .	42,097	19.9	Total, .	423,524	–
1889, . .	41,777	19.2	Mean, .	–	19.66

Deaths by Sexes. — The number of deaths of males recorded in 1893 was 24,899 and that of females was 24,185. Estimating the distribution of the sexes upon the same basis as in 1890, the death rates of the sexes were 21.02 per 1,000 for males and 19.29 for females.

TABLE 16. — *Mortality of the Sexes, Census Years and 1893.*

Years.	Deaths of Males.	Deaths of Females.	Death Rate of Males.	Death Rate of Females.	Deaths of Males to 1,000 Deaths of Females in Equal Numbers Living.
1860, . . .	11,444	11,547	19.3	18.4	1,048
1865, . . .	13,085	13,024	21.7	19.6	1,107
1870, . . .	13,699	13,598	19.5	18.6	1,048
1875, . . .	17,329	17,619	21.8	20.5	1,063
1880, . . .	17,426	17,852	20.3	19.3	1,052
1885, . . .	18,889	19,205	20.2	19.0	1,063
1890, . . .	21,767	21,761	20.0	18.9	1,058
1893, . . .	24,899	24,185	21.0*	19.3*	1,089*

* Estimated.

The disparity between the death rates of the sexes in Massachusetts was generally less than that of England, which was as 1,117 deaths of males to 1,000 deaths of females in equal numbers living for 1891, and as 1,102 to 1,000 for the whole period of registration (1838–93).

Deaths by Seasons.—In the following table are presented the statistics of deaths in Massachusetts by months and by sexes. For the purpose of presenting the seasonal mortality as fully and as clearly as possible, the method employed by Dr. Böckh of Berlin in his year book has been followed. The exceedingly accurate and careful statistical methods adopted in Berlin give to the mortality statistics of that city a value which cannot be attained here under present American modes of collection of statistics. The figures in columns 1, 2, 3, 5 and 6 may be taken as correct, while those in column 4 are subject to such slight corrections as the next census may require.

TABLE 17.—*Mortality by Months, Massachusetts (1893).*

MONTHS.	1 Males.	2 Females.	3 Totals.	4 Death Rate per 1,000.	5 Monthly Mortality Reduced to a Standard of 100 *	6 Deaths per Day.
January, . . .	2,027	2,134	4,161	20.23	99.8	134.2
February, . . .	1,905	1,809	3,714	19.99	98.6	132.6
March, ...	2,230	2,145	4,375	21.27	104.9	141.1
April, ...	2,253	2,082	4,335	21.63	107.4	144.5
May, ...	2,231	2,090	4,321	20.87	103.6	139.4
June, ...	1,654	1,596	3,250	16.22	80.5	108.3
July, ...	2,309	2,047	4,356	20.88	104.5	140.5
August, . . .	2,545	2,389	4,934	23.65	118.4	159.2
September, . . .	1,991	2,064	4,055	20.09	100.5	135.2
October, . . .	1,831	1,848	3,679	17.52	88.3	118.7
November, . . .	1,720	1,760	3,480	17.12	86.3	116.0
December, . . .	2,203	2,221	4,424	21.06	106.1	142.7
	24,899	24,185	49,084	20.13	100.0	134.5

* Column 5. In this column 100 is taken as the annual mean for a monthly period of uniform length.

In the foregoing table, in the figures presented in columns 4 and 5 the inaccuracies due to the unequal length of the months have been eliminated by comparing the daily number of deaths in each month with the mean daily number for the year. It is also quite plain that an estimate of population which may be applied in calculating the death rate in January and February cannot reasonably be applied to the same purpose in November and December, since the annual increase of the population, amounting in recent years to about 70,000 annually, is thus disregarded. Hence, in estimating the mortality rates given in column 4, a quarterly estimate has been adopted based upon the rate of growth from 1885 to 1890, after the

manner adopted by the Registrar General of England in his weekly reports. By this table it appears that the months in which the greatest daily number of deaths occurred were August, April and December, and those which had the least were June, November and October.

The percentages of deaths in each quarter of the year were as follows: —

In the first quarter,	25.0
In the second quarter,	24.3
In the third quarter,	27.1
In the fourth quarter,	23.6
	100.0

Deaths by Counties. — The number of deaths in each county during the three years 1891, 1892 and 1893, together with the death rates for 1890, were as follows, still-births being in every instance excluded in this table: —

TABLE 18. — *Deaths by Counties, 1891, 1892 and 1893, and Death Rates, 1890.*

	1891.	1892.	1893.	Death Rates, 1890.
THE STATE,	45,185	48,762	49,084	19.4
Barnstable,	615	640	592	19.4
Berkshire,	1,436	1,560	1,505	18.2
Bristol,	4,109	4,367	4,608	20.3
Dukes,	109	99	115	25.4
Essex,	5,916	6,272	6,064	20.0
Franklin,	699	766	654	15.8
Hampden,	2,644	3,181	2,999	19.6
Hampshire,	969	1,051	1,037	18.5
Middlesex,	8,506	9,038	9,420	18.4
Nantucket,	80	120	88	24.5
Norfolk,	1,945	2,087	2,294	16.5
Plymouth,	1,580	1,759	1,751	16.9
Suffolk,	11,357	12,013	12,280	22.3
Worcester,	5,220	5,809	5,677	17.8

NOTE. — Deaths and death rates of the urban population may be found on a later page.

Deaths by Ages. — No statement of mortality at different ages of life can have much value which fails to take into account the numbers of the living population at the same ages. In the absence of other figures the census must be the only guide, but in those States which

have a trustworthy system of registration of vital statistics the registration of births and that of the deaths of children under five years of age may be employed to correct the defects which are found to exist in all census enumerations of the first years of life. In the United States census of 1870 (volume on vital statistics), a method is proposed for the redistribution of the figures of these ages of life and for supplying deficiencies. The defects of distribution referred to are due chiefly to the tendency of parents to state the ages of children inaccurately.

The following figures illustrate this point:—

TABLE 19. — *Census of Children under Five Years of Age.*

Ages.	Population of			
	United States Census, 1880.	Massachusetts, 1885 (State Census).	Massachusetts, 1890 (U. S. Census).	England (1891).
0–1 year,	1,447,983	35,888	43,043	754,533
1 year,	1,256,956	27,327	28,462	691,590
2 years,	1,427,086	40,353	46,726	707,179
3 years,	1,381,274	38,064	44,367	706,274
4 years,	1,401,217	36,706	41,160	693,914
Total population,	50,155,783	1,942,141	2,238,943	29,002,525

Percentages of Total Population.

0–1 year,	2.89	1.85	1.92	2.60
1 year,	2.50	1.41	1.27	2.38
2 years,	2.85	2.08	2.09	2.44
3 years,	2.75	1.96	1.98	2.43
4 years,	2.79	1.89	1.84	2.39

It is quite apparent that the foregoing numbers for Massachusetts especially those for the first three years of life, are seriously defective, not only in their proper distribution, but also in actual omissions of considerable numbers, when the births and the deaths of infants under one and successive ages are considered. Hence an adjusted table for the first five years becomes necessary, either with or without the actual addition of some assumed number. Mr. Elliott assumes the number 100,000 as a proposed addition to the United States census figures for the whole population of the United States in 1870, in the first five years of life. It is possible, however, to arrive at a more defi-

nite estimate in Massachusetts, in consequence of the existence in this State of a careful system of registration of births, marriages and deaths. A careful estimate in Massachusetts, deduced from the births and the deaths in the first years of life, leads to the conclusion that the omissions in this period (0–5 years) constitute a still greater ratio of the total population of the State in the two last census enumerations, than is represented by the number 100,000 as compared with the United States population of 1870.*

An examination of the figures presented in the table on the preceding page shows in each column certain peculiarities in the numbers representing the first three years of life. In each instance the number of children living in the period one to two years, shown in the second line of figures, is considerably less than that of either the preceding or the succeeding year, and in the two columns for Massachusetts the figures for the period two to three years (third line) are greater in each instance than those of infants under one (first line). These points are simplified by the percentages presented in the second part of the table.

In a fixed population, in which migration plays no part, these figures should present a successive diminution from the age period 0–1 onwards, the rate of diminution being dependent upon the mortality at different ages. Migration affects principally the adult ages of life, and in rough estimates of the first three years or more, its direct effect may practically be ignored.†

After reviewing the method proposed by Mr. Elliott and the methods usually adopted for the construction of life tables, the following percentages have been adopted for estimating the mortality rates of the first five years of life, and for those which relate to the diseases of childhood for the census years 1885–90 in Massachusetts.

* Mr. Henry Gannett, in a recent contribution to the quarterly publications of the American Statistical Society, estimates the total deficiency of the U. S. census of 1890 at one million persons. — Publications Am. Statistical Soc., Vol. IV., page 99.

† The percentages of immigrants to United States by ages for fifty years were as follows: —

0- 5,	7.9	30-35,	9.8
5-10,	7.2	35-40,	6.7
10-15,	6 9	40 and over,	10 2
15-20,	14 3		
20-25,	20.9		100.00
25-30,	16.1		

More than one-half were between the ages of fifteen and thirty years. The addition of a considerable number of immigrants to the population of ages 15-30 can have scarcely an appreciable effect upon the death rate. If the additions were mainly of children of ages 5-15, the death rate would be diminished; if the additions were chiefly of ages above 30, the death rate would be materially increased thereby.

These percentages are calculated both for redistribution and for addition of sufficient numbers to conform to the figures for age mortality.

TABLE 20.

Ages.	Percentages of Total Population.	
	1885.	1890.
0–1 year,	2.10	2.12
1 year,	2.00	2.03
2 years,	1.94	1.98
3 years,	1.91	1.95
4 years,	1.88	1.93

These percentages differ but little from those which may be found in life tables. The difficulty of constructing such tables accurately for migratory populations, like those of American States, as compared with the more stationary or fixed populations of European countries, must be recognized.

In summing up this question in the twelfth volume of the tenth census, page cxliii, Dr. Billings says: "The preparation for any given locality, race or occupation, *in this country*, of a life table which shall accurately represent the tendency to death or the probability of survival at each age is practically impossible, because of the want of accuracy in the necessary data, and because of the irregular migrations of the population. It should be clearly understood that all tables of vital statistics, including data from large numbers of people, even when these are obtained by the most accurate census possible, and by the most complete system of registration which can be enforced, give probabilities only, and that scientific accuracy in this field is practically unattainable."

Dr. Farr says, in commenting upon this subject, "The years of infant life cannot be accurately deduced from decennial enumerations of the infants living at the date of the census. . . . The difficulties arise from the want of exactly observed facts."

A comparison of the mortality of children under one year of age with the births constitutes the most accurate method of estimating the infant mortality for any given year, since the registration of

births may be deemed to be fairly complete, the deficiencies amounting probably to less than one per cent.*

The following table presents the mortality of infants under one year, as compared with living births for the twenty years, 1874–93 : —

TABLE 21. — *Infant Mortality. Ratio of Deaths under One Year to Living Births per 1,000.*

1874, .	164.3	1879, .	142.8	1884, .	158.9	1889, .	162.2
1875, .	172.0	1880, .	169.5	1885, .	156.5	1890, .	166.5
1876, .	154.6	1881, .	165.2	1886, .	159.5	1891, .	169.0
1877, .	152.4	1882, .	164.4	1887, .	162.6	1892, .	166.5
1878, .	148.7	1883, .	163.3	1888, .	164.9	1893, .	165.3

Mean, 1874–93, 161.9.

NOTE. — The figures in this table are obtained by comparing the deaths of infants under one in each year with the births which occurred in the twelve months ending with June 30 of the same year, since about one-half of the deaths of infants under one, occurring in each year, were those of infants who were born in the year immediately preceding.

The foregoing mean constitutes the ratio of 160,914 deaths of infants under one year to 993,807 living births.

The extremes during the past forty-five years were 119.1 per 1,000 births in 1857 and 202.7 in 1872.

Deaths at Extreme Old Age. — The number of deaths of persons who had lived to the age of ninety years and over in 1893 was 465. Of this number, 370 were from ninety to ninety-five years of age at death, 77 were from ninety-five to one hundred, and 18 were one hundred years and over.

Of the whole number who died at ages beyond ninety years, 152 were men and 313 were women, or in the ratio of 100 men to 206 women.

* "The mortality of infants under one year, calculated with reference to the number of births during the year, is, perhaps, the best single test of sanitary condition which we can have." — BILLINGS, Vital Statistics, "The Sanitary Engineer," January, 1884, page 163.

Causes of Death.

The system of classification of diseases and causes of death proposed by Dr. Wm. Farr has been in use among English-speaking nations with occasional modifications for nearly half a century, and that of Professor Virchow in Germany since 1873. It now becomes an important question whether a revision of existing classifications is not desirable, in order that the grouping of diseases or causes of death may be consistent with the progress of medical science. The chief advantage of retaining old and well-known classifications lies in the facility of comparison of the statistics of different years or periods of time. In the course of time, however, these groupings lose their significance, and gradually manifest a lack of harmony with prevailing systems of pathology. Groupings or general divisions, comprising several causes of death in one class, have less significance than the same diseases considered separately. The class of so-called developmental diseases or causes of death, for example, conveys but little meaning as a whole. The general class of local diseases so long in use is much less significant as a whole than the subdivisions of which it is composed. The class of deaths by violence is quite distinct, and must necessarily be subject to less change than the others. The transfer of tuberculosis to a place among infectious diseases appears to be an inevitable conclusion, and this transfer of more than ten per cent. of the total mortality from one group or class to another necessarily disturbs the statistical comparison in a very marked degree. This change already appears in the nosological tables of some countries and cities of considerable size.

Hence, in the following discussion of the causes of death in Massachusetts for 1893, but little prominence will be given to the general groupings of causes of death, and single causes of death which have unusual import will be treated with considerable fulness of detail. These comprise chiefly the principal infectious diseases, together with those local diseases which are very destructive to life.

In the following table the old classification is retained for the present, for the purpose of comparison: —

TABLE 22. — *Causes of Death, by Classes. Ratio per 10,000 of the Population.*

Years	I. Infectious Diseases.	II. Constitutional Diseases.	III. Local Diseases.	IV. Developmental Diseases.*	V. Deaths from Violence.
1865,	64.87	51.63	50.79	26.48	7.34
1870,	47.45	49.30	51.85	21.87	7.79
1875,	58.96	49.40	65.44	23.16	8.61
1880,	47.41	45.89	73.73	19.52	7.19
1885,	36.74	45.94	82.76	20.65	7.48
1889,	36.92	41.36	83.57	20.10	7.78
1890,	36.09	41.14	87.13	19.63	8.10
1891,	35.87	39.26	91.20	20.05	8.04
1892,	39.02	39.34	96.50	20.12	8.78
1893,	35.84	38.50	96.25	19.41	9.08
Mean (five years) 1889-93,	36.75	39.87	91.12	19.86	8.37

* Still-births excluded.

By this table it appears that very marked changes have taken place in the groups marked I., II. and III., the first two having notably decreased, while the third has quite as notably increased.

The following table presents the mortality from the ten most prominent causes of death in Massachusetts for the ten years 1884 to 1893, in the order of their prominence: —

TABLE 23. — *Mortality from Ten Prominent Causes. — 1884–1893.*

CAUSES OF DEATH.	Deaths. 1893.	1893.	1892.	1891.	1890.	1889.	1888.	1887.	1886.	1885.	1884.
Consumption,	5,527	1	1	1	1	1	1	1	1	1	1
Pneumonia,	5,499	2	3	3	3	3	3	3	3	3	3
Brain diseases,*	5,144	3	2	2	2	2	2	2	2	2	2
Heart diseases,	3,696	4	4	4	4	4	4	4	4	4	4
Cholera infantum,	2,704	5	5	5	6	5	5	5	5	6	5
Old age,	1,861	6	6	6	7	7	6	6	6	5	6
Bronchitis,	1,738	7	7	7	10	10	8	8	10	8	10
Kidney diseases,	1,685	8	8	8	9	9	9	10	8	9	9
Cancer,	1,533	9	10	9	8	8	10	9	9	10	8
Diphtheria and croup,	1,394	10	9	10	5	6	7	7	7	7	7

* Including deaths certified as from apoplexy, paralysis, insanity, inflammatory diseases of the brain and its membranes, and other brain diseases.

From this table it appears that consumption has maintained its position at the head of the list for the whole decade, although very closely approached by pneumonia in 1893. Brain diseases held the second place from 1884 to 1891, and for the two years, 1892 and 1893, was displaced by pneumonia. Diphtheria and croup attained the seventh place for the first five years, and then rose to the fifth, but finally fell to the last place in 1891 and 1893.

Statistics of Certain Causes of Death, Massachusetts, 1893.

In the tables 24, 25, 26, 27 and 28 are presented the principal statistics relative to the following causes of death: —

Small-pox.
Measles.
Scarlet-fever.
Diphtheria and croup.
Typhoid fever.
Cholera infantum.
Consumption.
Pneumonia.
Whooping-cough.
Cancer.
Kidney diseases.
Heart diseases.
Brain diseases.

The data presented are the following: —

Number of deaths from each of the foregoing causes in each year for twenty years (1874–1893), ...	Table 24
Death rate from each of the same causes per 10,000 of the living population for each year, ...	" 24
Percentage of the total mortality for each year, ...	" 24
The means for the twenty-year period, ...	" 24
The total deaths and deaths for each sex from each of ten causes of death for the thirty-three years (1861–1893), ...	" 25
The deaths in each month from each of the same causes for the same period, ...	" 25
The deaths at each of eleven ages for the same period from each of ten causes, ...	" 25
The monthly ratio of deaths reduced to a standard of 100 with the inequalities of time eliminated, ...	" 26
The death rate per 10,000 living from each of these ten causes for the same period, ...	" 27
The death rate of each sex from each of these causes for the same period,	" 27
The average annual mortality at each age period, compared with the living population at each age, expressed as a ratio per 10,000 of the living population. In this table the error due to the inaccuracies and deficiencies in the census distribution of the first years of life, represented in the age period 0–5, has been corrected upon an approximate basis, ...	" 27
The mortality statistics of the year 1893 from the same causes, the ratios being omitted, ...	" 28

TABLE 24.—STATISTICS OF CERTAIN CAUSES OF DEATH, MASSACHUSETTS, 1874–93.

Deaths, and Ratios compared with Population and Mortality from All Causes.

	Small-pox.			Measles.			Scarlet-fever.			Diphtheria and Croup.			Typhoid Fever.			Cholera Infantum.			Consumption.		
	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.
1874, ...	26	.2	.08	161	1.0	.50	1,382	8.6	4.33	913	5.6	2.86	1,147	7.1	3.6	2,322	14.4	7.28	5,284	32.8	16.57
1875, ...	34	.2	.09	233	1.4	.67	1,684	10.2	4.81	1,880	11.4	5.31	1,059	6.4	3.02	2,606	15.8	7.45	5,738	34.7	16.40
1876, ...	31	.2	.09	47	.3	.14	1,222	7.3	3.68	3,294	19.6	9.92	881	5.3	2.65	2,087	12.4	6.29	5,327	32.2	16.05
1877, ...	24	.14	.08	135	.8	.44	467	2.7	1.49	3,178	18.7	10.14	814	4.8	2.59	1,927	11.3	6.15	5,457	32.0	17.41
1878, ...	2	.01	.01	305	1.8	.97	404	2.2	1.29	2,517	14.6	8.04	679	3.9	2.16	1,573	9.1	5.02	5,334	30.8	17.04
1879, ...	7	.04	.02	19	.1	.06	850	4.8	2.67	2,293	13.1	7.21	637	3.6	2.00	1,349	7.7	4.24	5,223	29.7	16.42
1880, ...	38	.21	.11	236	1.3	.67	574	3.2	1.63	2,394	13.4	6.78	882	4.9	2.50	2,118	11.9	6.00	5,494	30.8	15.57
1881, ...	47	.25	.13	230	1.3	.63	397	2.2	1.09	2,383	13.1	6.54	1,072	5.9	2.94	1,861	10.3	5.10	5,886	32.4	16.14
1882, ...	45	.24	.12	68	.4	.18	318	1.7	.86	1,771	9.6	4.81	1,079	5.8	2.93	2,159	11.7	5.87	5,865	31.8	15.93
1883, ...	5	.03	.01	321	1.7	.85	575	3.1	1.52	1,621	8.6	4.29	860	4.6	2.28	1,941	10.3	5.14	5,931	31.6	15.71
1884, ...	3	.01	.01	75	.4	.20	627	3.3	1.69	1,646	8.6	4.45	875	4.6	2.36	2,081	10.9	5.62	5,798	30.4	15.67
1885, ...	19	.10	.05	313	1.6	.82	587	3.0	1.54	1,523	7.8	3.98	768	3.9	2.02	1,852	9.5	4.86	5,955	30.7	15.63
1886, ...	-	-	-	130	.6	.35	331	1.7	.89	1,558	7.8	4.18	800	4.0	2.15	1,931	9.7	5.18	5,897	29.5	15.83
1887, ...	3	.01	.007	455	2.2	1.12	594	2.9	1.46	1,628	7.9	3.99	922	4.5	2.26	2,131	10.4	5.23	5,871	28.6	14.40
1888, ...	8	.04	.02	219	1.0	.52	504	2.4	1.20	1,831	8.7	4.35	943	4.5	2.24	2,195	10.4	5.21	5,728	27.1	13.61
1889, ...	6	.03	.01	171	.8	.41	185	.8	.44	2,214	10.2	5.30	891	4.1	2.13	2,156	9.9	5.16	5,581	25.7	13.36
1890, ...	1	.004	.002	114	.5	.26	196	.9	.45	1,626	7.3	3.74	835	3.7	1.92	2,491	11.1	5.72	5,791	25.9	13.31
1891, ...	1	.004	.002	236	1.0	.52	246	1.1	.54	1,218	5.3	2.69	821	3.6	1.82	2,771	12.0	6.13	5,484	23.8	12.14
1892, ...	2	.01	.004	88	.4	.18	669	2.8	1.37	1,455	6.1	2.98	827	3.5	1.69	2,898	12.2	5.94	5,739	24.2	11.77
1893, ...	9	.04	.02	276	1.1	.56	810	3.3	1.65	1,394	5.7	2.84	750	3.1	1.53	2,704	11.1	5.51	5,527	22.7	11.26
Totals and means,	311	.08	.04	3,832	.9	.50	12,622	3.2	1.65	38,337	9.8	5.01	17,542	4.5	2.30	43,153	11.1	5.65	112,910	29.0	14.77

STATISTICS OF CERTAIN CAUSES OF DEATH, MASSACHUSETTS, 1874-93 — Concluded.

Deaths, and Ratios compared with Population and Mortality from All Causes — Concluded.

	PNEUMONIA.			WHOOPING-COUGH.			CANCER.			KIDNEY DISEASES.			HEART DISEASES.			BRAIN DISEASES.		
	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.
1874,	2,386	14.8	7.49	449	2.8	1.41	585	3.6	1.83	463	2.9	1.45	1,272	7.9	3.99	2,413	15.0	7.57
1875,	2,940	17.8	8.40	242	1.5	.69	593	3.5	1.69	509	3.1	1.45	1,331	8.1	3.80	2,590	15.7	7.40
1876,	2,447	14.6	7.37	192	1.1	.58	657	3.9	1.98	488	2.9	1.47	1,335	8.0	4.02	2,507	14.9	7.55
1877,	1,972	11.6	6.29	369	2.2	1.18	646	3.8	2.06	535	3.1	1.71	1,355	7.9	4.32	2,521	14.8	8.04
1878,	2,171	12.6	6.93	400	2.3	1.28	807	4.7	2.58	615	3.6	1.96	1,442	8.4	4.61	2,778	16.1	8.87
1879,	2,647	15.0	8.32	302	1.7	.95	862	4.9	2.71	693	3.9	2.18	1,515	8.6	4.76	2,820	16.1	8.87
1880,	3,076	17.2	9.71	230	1.3	.65	928	5.2	2.63	698	3.9	1.98	1,726	9.7	4.89	3,210	18.0	9.10
1881,	2,967	16.4	8.14	217	1.2	.59	949	5.2	2.60	825	4.5	2.27	1,937	10.7	5.31	3,355	18.5	9.20
1882,	2,932	15.9	7.97	265	1.4	.72	987	5.3	2.68	877	4.7	2.38	2,025	11.0	5.50	3,393	18.4	9.22
1883,	3,045	16.2	8.07	137	.7	.36	1,026	5.5	2.72	959	5.1	2.54	2,153	11.5	5.70	3,562	19.0	9.44
1884,	2,646	13.7	7.15	410	2.1	1.11	1,060	5.6	2.86	1,000	5.2	2.70	2,117	11.1	5.72	3,669	19.2	9.92
1885,	3,468	17.9	9.10	184	.9	.48	1,087	5.6	2.85	1,088	5.6	2.86	2,227	11.5	5.85	3,894	20.0	10.22
1886,	2,836	14.2	7.61	271	1.4	.73	1,104	5.5	2.96	1,135	5.7	3.05	2,325	11.6	6.24	3,844	19.2	10.32
1887,	3,348	16.3	8.21	232	1.1	.57	1,174	5.7	2.88	1,120	5.4	2.75	2,690	13.1	6.60	4,257	20.7	10.44
1888,	3,716	17.6	8.83	245	1.2	.58	1,275	6.0	3.03	1,318	6.2	3.13	3,061	14.5	7.27	4,522	21.4	10.74
1889,	3,440	15.8	8.23	310	1.4	.74	1,325	6.1	3.17	1,258	5.8	3.01	3,280	14.2	7.85	4,313	19.8	10.32
1890,	4,038	18.0	9.28	363	1.6	.83	1,387	6.2	3.19	1,273	5.7	2.92	3,417	15.3	7.85	4,389	19.6	10.08
1891,	4,337	18.8	9.60	219	.9	.48	1,395	6.1	3.09	1,474	6.4	3.26	3,592	15.6	7.95	4,711	20.5	10.42
1892,	5,020	21.2	10.29	248	1.0	.51	1,402	5.9	2.87	1,535	6.5	3.15	3,733	15.7	7.65	5,036	21.2	10.33
1893,	5,499	22.6	11.20	271	1.1	.56	1,533	6.3	3.12	1,685	6.9	3.43	3,511	14.4	7.15	5,144	21.1	10.48
Totals and means,	64,931	16.6	8.50	5,559	1.4	.73	20,782	5.3	2.72	19,548	5.0	2.56	46,044	11.8	6.02	72,928	18.7	9.54

TABLE 25. — *Number of Deaths from Several Specified Causes, of Each Sex, in Each Month, and at Different Specified Periods of Life, which were Registered during Thirty-three Years (1861–1893).*

		Small-pox.	Measles.	Scarlet-fever.	Diphtheria.	Croup.	Typhoid Fever.	Dysentery.	Cholera Infantum.	Consumption.	Pneumonia.
	Totals,	3,418	6,827	27,115	35,051	16,905	33,861	16,237	63,303	175,005	86,746
SEX.	Males,	2,038	3,425	13,457	16,812	8,942	17,872	7,893	33,669	79,764	44,180
	Females,	1,377	3,400	13,652	18,228	7,957	15,983	8,331	29,595	95,226	42,560
	Unknown,	3	2	6	11	6	6	13	39	15	6
MONTHS.	January,	480	471	3,091	3,685	2,037	2,251	177	282	15,214	11,856
	February,	312	532	2,637	2,891	1,635	1,765	176	237	13,959	10,135
	March,	293	673	3,018	2,699	1,667	1,907	209	301	16,091	11,569
	April,	280	847	2,767	2,565	1,354	1,868	218	353	15,625	10,782
	May,	327	966	2,665	2,620	1,089	1,739	249	495	15,682	8,562
	June,	210	913	2,108	2,344	767	1,566	442	1,754	13,424	4,506
	July,	190	788	1,616	2,071	584	1,937	2,350	18,300	13,898	3,048
	August,	117	495	1,364	1,978	612	3,535	5,548	24,688	14,427	2,467
	September,	157	230	1,239	2,591	988	5,015	4,330	12,358	14,147	3,016
	October,	223	203	1,696	3,754	1,717	5,381	1,810	3,517	14,324	4,672
	November,	315	298	2,251	3,870	2,181	3,922	489	715	13,734	6,584
	December,	514	409	2,658	3,979	2,273	2,960	234	301	14,455	9,544
	Not stated,	–	2	5	4	1	15	5	2	25	5

	Totals,	3,418	6,826	27,115	35,051	16,905	33,861	16,237	63,303	175,015	86,746
Ages.	Under 5,	1,117	5,552	17,926	19,424	14,314	2,505	8,152	63,289	9,299	26,844
	5 to 10,	237	588	6,698	10,211	2,344	2,000	1,008	7	1,696	2,346
	10 to 15,	114	114	1,344	2,627	133	2,464	285	–	3,257	946
	15 to 20,	290	126	466	841	27	5,006	244	–	16,140	2,031
	20 to 30,	906	199	418	829	18	8,992	572	–	50,819	5,663
	30 to 40,	346	77	134	449	19	4,150	593	–	34,723	6,633
	40 to 50,	149	53	32	234	8	2,630	670	–	22,107	7,574
	50 to 60,	104	30	24	142	9	2,069	853	–	15,066	8,402
	60 to 70,	60	25	14	126	2	1,923	1,202	–	12,291	10,442
	70 to 80,	32	29	5	74	3	1,458	1,503	–	7,380	10,102
	Over 80,	20	13	1	16	2	523	1,085	–	1,640	5,516
	Not stated,	43	20	53	78	26	141	70	7	597	247

TABLE 26. — *Mortality by Months, reduced to a Standard Mean of 100. — Thirty-three Years (1861–1893).*

Months.	Small-pox.	Measles.	Scarlet-fever.	Diphtheria.	Croup.	Typhoid Fever.	Dysentery	Cholera Infantum.	Consumption.	Pneumonia.
January,	165.36	81.25	134.25	123.81	141.89	78.40	12.84	5.25	102.36	160.93
February,	119.00	101.60	126.81	107.54	126.09	68.06	14.14	4.87	103.99	152.31
March,	100.94	116.09	131.08	90.68	116.12	66.41	15.17	5.60	108.27	157.02
April,	99.67	150.98	124.14	89.05	97.46	67.23	16.34	6.79	108.64	151.23
May,	112.65	166.64	115.75	88.03	75.86	60.57	18.06	9.21	105.52	116.23
June,	74.75	162.75	94.65	81.38	55.21	56.36	33.13	33.72	93.34	63.20
July,	65.45	135.93	70.19	69.58	40.68	67.46	170.47	340.42	93.52	41.37
August,	40.30	85.39	59.24	66.46	42.63	123.12	402.45	459.25	97.08	33.49
September,	55.89	41.00	55.61	89.96	71.11	180.49	324.56	237.55	98.37	42.30
October,	76.82	35.02	73.66	126.13	119.60	187.41	131.30	65.42	96.38	63.55
November,	112.14	53.12	101.03	134.36	156.98	141.15	36.65	13.74	95.49	92.35
December,	177.07	70.55	115.44	133.69	158.33	103.09	16.97	5.60	97.27	129.55
Mean,	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

NOTE. — In this table the error due to unequal lengths of the months is eliminated.

TABLE 27. — *Average Annual Mortality for Each Sex and at Each Age Period compared with the Living Population of Each Sex and Each Period, expressed as a Ratio per 10,000 of the Living Population (1861–1893).*

		Small-pox.	Measles.	Scarlet-fever.	Diphtheria.	Croup.	Typhoid Fever.	Dysentery.	Cholera Infantum.	Consumption.	Pneumonia.
	Totals,	.60	1.20	4.77	6.16	2.97	5.95	2.85	11.13	30.77	15.25
SEX.	Males,	.74	1.25	4.91	6.14	3.26	6.53	2.88	12.29	29.13	16.13
SEX.	Females,	.47	1.15	4.62	6.18	2.70	5.42	2.82	10.04	32.29	14.43
AGES.	Under 5,	1.88	9.36	30.18	32.70	24.10	4.22	13.56	106.55	15.65	45.19
AGES.	5 to 10,	.43	1.07	12.23	18.64	4.28	3.65	1.84	.01	3.10	4.28
AGES.	10 to 15,	.22	.22	2.56	5.01	.25	4.70	.54	–	6.21	1.80
AGES.	15 to 20,	.53	.23	.82	1.54	.05	9.15	.63	–	29.50	3.71
AGES.	20 to 30,	.82	.18	.38	.75	.02	8.15	.52	–	46.08	5.13
AGES.	30 to 40,	.41	.09	.16	.53	.02	4.92	.70	–	41.15	7.86
AGES.	40 to 50,	.23	.08	.05	.36	.01	4.09	1.04	–	34.41	11.79
AGES.	50 to 60,	.23	.07	.05	.32	.02	4.65	1.92	–	33.89	18.90
AGES.	60 to 70,	.21	.09	.05	.45	.01	5.16	4.25	–	43.46	36.92
AGES.	70 to 80,	.24	.21	.04	.55	.02	10.76	11.07	–	54.48	74.57
AGES.	Over 80,	.48	.31	.02	.38	.05	12.49	25.91	–	39.16	131.73

TABLE 28. — *Number of Deaths from Several Specified Causes, of Each Sex, in Each Month and at Different Specified Periods of Life, which were Registered during the Year 1893.*

	THE YEAR 1893.	Small-pox.	Measles.	Scarlet-fever.	Diphtheria.	Croup.	Typhoid Fever.	Dysentery.	Cholera Infantum.	Consumption.	Pneumonia.
	Totals,	9	276	810	1,072	322	750	231	2,704	5,527	5,499
SEX.	Males,	2	126	391	526	171	425	97	1,423	2,627	2,926
	Females,	7	150	419	546	151	325	134	1,281	2,900	2,573
MONTHS.	January,	1	20	110	119	36	57	5	15	476	660
	February,	2	18	76	76	33	43	1	13	414	612
	March,	1	26	100	85	36	34	4	17	509	690
	April,	–	28	78	73	28	45	5	18	528	800
	May,	–	54	91	76	32	35	10	18	530	659
	June,	1	37	63	59	16	41	6	69	433	267
	July,	–	23	46	75	15	39	29	767	458	192
	August,	–	16	34	64	12	68	57	1,108	432	121
	September,	–	10	34	71	13	107	68	520	437	147
	October,	–	11	54	129	22	120	23	114	429	237
	November,	–	18	56	135	33	89	18	35	435	345
	December,	4	15	68	110	46	72	5	10	446	769

	Totals,	9	276	810	1,072	322	750	231	2,704	5,527	5,499
Ages.	Under 5,	2	227	512	670	269	20	72	2,700	215	1,399
	5 to 10,	1	19	219	278	51	35	4	3	53	134
	10 to 15,	–	5	37	51	1	44	2	–	117	54
	15 to 20,	2	4	18	23	1	115	1	–	495	131
	20 to 30,	4	3	16	22	–	221	9	–	1,764	384
	30 to 40,	–	8	5	10	–	155	10	–	1,258	513
	40 to 50,	–	3	–	9	–	61	10	–	685	599
	50 to 60,	–	2	–	4	–	40	15	–	446	609
	60 to 70,	–	1	1	3	–	35	34	–	286	721
	70 to 80,	–	2	–	1	–	19	45	–	168	595
	Over 80,	–	2	–	–	–	3	28	–	36	350
	Not stated,	–	–	2	1	–	2	1	1	4	10

Small-pox.

The number of deaths for the twenty-year period 1874–93 is presented in Table 24, together with the death rate and the percentage of the total mortality for each year. The numbers were extremely variable, and ranged from 47 deaths in 1881 to 0 in 1886. The greatest number in any one year during the past half-century was 1,029, in 1872. The whole number of registered deaths from this disease in the twenty-year period 1854–73 was 4,412, and that of the period 1874–93 was 311. The annual mortality per 10,000 of the living population in the former period was 1.7, and that of the latter period was only .08.

Sex. — In Table 27 it appears that the mortality of males from small-pox was greater than that of females, in the ratio of .74 per 10,000 of the living males to .47 per 10,000 of living females, or in the ratio of 157 males to 100 females for the period of thirty-three years, 1861–93.

Seasons of the Year. — Upon a mean monthly standard of 100 the greatest mortality from this cause occurred in December (177.1) and the least in August (40.3).

Age. — The effect of age upon the mortality from small-pox is shown in Table 27, wherein the deaths at each age are compared with the living population at the same age of life. This table embraces a period of thirty-three years (1861–93). The death rates at different ages are considerably less in each instance than those presented in the Registration Report of 1890, in consequence of the addition to the present table of the statistics of five additional years, 1861–62, 1891–93, in each of which the deaths from small-pox were below the mean annual number of the period. The highest death rate of any age (1.88 per 10,000 living) was that of the first period (0–5 years), the next highest (.82) that of the period 20–30 years, while the lowest (.21 and .22) were those of the age periods 60 to 70 and 10 to 15 years.

(Further information relative to the influence of vaccination and that of other conditions on small-pox mortality may be found on pages viii–xxiii in the General Report, under the title of "Infectious Diseases.")

Measles.

The deaths from measles in Massachusetts in 1893 were 276, and the death rate per 10,000 of the population was 1.1, as compared with 88 deaths and a death rate of .4 per 10,000 in 1892, and an annual mean of .9 for the twenty-year period (1874–93). The maximum death rate of the period was 2.2 per 10,000 in 1887 and the minimum was .1 in 1879. (See Table 24.)

Sex. — The mortality of males from this cause in 1893 was less than that of females, but for the whole period (1861–93) the mortality of males was greater than that of females, in the ratio of 1.25 to 1.15 per 10,000 living, or as 109 males to each 100 females in equal numbers living.

Seasons of the Year. — The greatest mortality from measles in any month of 1893 occurred in May and the least in September. For the whole period of thirty-three years (1861–93), upon a monthly standard of 100 the figures were a maximum of 166.6 for May and a minimum of 35.0 for October.

Age. — By far the greatest number of deaths from measles in 1893 occurred in the age period 0–5 years, the deaths of persons over 10 years of age being comparatively few. For the whole period of thirty-three years the highest mortality from measles (9.36 per 10,000 living at the same age of life) was in the period of infancy (0–5), and the lowest (.07) was in the period 50–60 years.

In consequence of the demand for a more thorough consideration of the mortality from the diseases of childhood and of a finer division of age periods than has hitherto been presented, the mortality from such diseases has been (at the suggestion of the State Board of Health) expressed in separate years for each of the years under 5, since and including 1887, in each of the State Registration Reports, and the statistics of certain children's diseases for the separate years up to 5, including measles, will be found on a later page.

Scarlet-fever.

The deaths from scarlet-fever in 1893 were 810 and the death rate 3.3 per 10,000 of the population, as compared with 669 deaths and a death rate of 2.8 from the same cause in 1892, and an annual mean of 3.2 for the twenty-year period, 1874–93. The maximum death rate of the period from this cause was 10.2 per 10,000 in 1875, and the minimum was .8 in 1889.

Sex. — The deaths of males in 1891 were slightly less than those of females, but for the thirty-three-year period 1861–93 the death rate of males was greater in the ratio of 4.91 males per 10,000 living to 4.62 females, or as 106 males to 100 females in equal numbers living.

Seasons of the Year. — The greatest mortality from scarlet-fever in any month in 1893 occurred in January and the least in August. Upon a monthly standard of 100 the figures show a maximum of 134.2 for January for the thirty-three-year period (1861–93), and a minimum of 55.6 for September.

Age. — The deaths of children under five from scarlet-fever were 512, and those of children from 5 to 10 years were 219, and these deaths constituted 90 per cent. of the total mortality from scarlet-fever in the year 1893.

For the thirty-three-year period (1861–93) the death rate from this cause among children under 5 years of age was 30.2 per 10,000 of the population of that age, the death rate diminishing for each successive age period to a ratio of only .05 per 10,000 for the ages 40–70 and still less in old age. The deaths and death rates for the separate single years from 0 to 5 will be found on a later page.

Diphtheria and Croup.

The deaths from diphtheria and croup in 1893 were 1,394 and the death rate 5.7 per 10,000 of the population, as compared with 1,455 and a death rate of 6.1 per 10,000 in 1892, and an annual mean of 9.8 for the twenty-year period (1874–93). The maximum death rate for the period from diphtheria and croup was 19.6 in 1876 and the minimum was 5.3 in 1891.

Sex. — The deaths of males and females in 1893 were exactly equal, being 697 for each sex. But for diphtheria the deaths of females exceeded those of males by 20, and for croup those of males were the greater by 20; and, since the numbers of males and females in the living population are nearly equal in the first five years of life, these numbers are fairly comparable. For the whole period of thirty-three years (1861–93) the death rate of males from diphtheria was less than that of females, in the ratio of 6.14 males per 10,000 to 6.18 females, or as 99 males to 100 females in equal numbers living.

Seasons of the Year. — The greatest mortality from these combined causes in 1893 was in November (168 deaths) and the least

was in June (75). Upon a monthly standard of 100 for the period 1861–93, the greatest mortality from diphtheria (134.4) occurred in November and the least (66.5) in August. That of December (133.7) was nearly as great as that of November.

For croup the highest monthly mortality, upon the same basis (158.3), was in December and the least was in July (40.7). In this instance also the mortality for November (156.98) was nearly identical with that of December.

Age. — The deaths of children under 5 from diphtheria in 1893 were 670, and there were 269 from croup, and those of children from 5 to 10 years of age from the same causes were respectively 278 and 51. From diphtheria there were 123 deaths of persons over 10 years of age, and from croup there were only 2.

For the thirty-three-year period (1861–93) the death rate of children under 5 from diphtheria was 32.7 per 10,000 living of the same age, and for the next period (5–10 years) it was 18.6 per 10,000, and diminishing for each successive period to the age 40–50, when it was .36, and then remaining nearly the same with but little variation up to old age.

The death rate of children under 5 from croup for the same period was 24.1 per 10,000 living of the same age, that of the age 5–10 was 4.3 per 10,000, while that of all succeeding ages from croup was extremely slight.

Typhoid Fever.

The deaths from typhoid fever in 1893 were 750 and the death rate per 10,000 was 3.1, as compared with 827 deaths and a death rate of 3.5 in 1892. The mean death rate of the twenty-year period was 4.5 per 10,000. The maximum death rate from this cause was 7.1 in 1874, the first year, and the minimum was 3.1 in 1893, the last year of the period, the diminution throughout the period being comparatively uniform.

Sex. — The deaths of males were 425 and those of females were 325 in 1893. For the thirty-three-year period the death rate of males was 6.53 and that of females was 5.42 per 10,000, or in the ratio of 120 males to 100 females in equal numbers living.

Seasons of the Year. — The greatest mortality from typhoid fever occurred in September and October and the least in March and May. For the thirty-three-year period (1861–93) the maximum mortality on a monthly standard of 100 was 187.4 in October and the minimum (56.4) was in June.

Age. — Of the 750 registered deaths from typhoid fever in 1893, 491, or 65½ per cent., were those of persons between 15 and 40 years of age.

The following figures show the death rates at different ages from typhoid fever, both for the year 1893 and for the thirty-three-year period (1861–93). They are here introduced because not only has the general death rate from this disease diminished, but the death rates at the different ages have undergone marked changes when considered in relation to each other, the greatest changes having taken place at the extremes of life Coincident with this fact it should be noted that in the earliest years of this period (1861–93) the distinctive characteristics of typhoid and typhus fevers were not so sharply defined as at present, and cases of the latter disease are undoubtedly included in the early statistics of the long period.

The relative mortality from typhoid fever at different ages of life shows a comparatively uniform incidence for the youngest ages up to 60 years, with a considerable increase between the ages of 15 and 30, and a more decided increase from 60 to the close of life, for the thirty-three years 1861–93. For the year 1893 there is an increase with considerable uniformity from the earliest period up to the age period 15–30 years, while for the remainder of life up to 70 years the ratio presents a similar average rate to that of the period 10–15 years, the ratio for each period being generally less than those of the group of years 1861–93. The figure 1.58 for the old-age period, 80 +, for 1893, must be regarded as having but little significance, since it represents the ratio for 3 deaths only, while that of the thirty-three-year period represents 523 deaths.

TYPHOID FEVER.

Death Rates per 10,000 for the Population Living at Each Age Period.

AGES.	1861-93.	1893.
0-5, ...	4.22	0.91
5-10, ...	3.65	1.67
10-15, ...	4.70	2.12
15-20, ...	9.15	4.96
20-30, ...	8.15	4.40
30-40, ...	4.92	4.21
40-50, ...	4.09	2.24
50-60, ...	4.65	2.09
60-70, ...	5.16	2.87
70-80, ...	10.76	3.11
80 and over, . .	12.49	1.58

Cholera Infantum.

The number of deaths from cholera infantum registered in 1893 was 2,704, and the death rate was 11.1 per 10,000 of the living population, as compared with 2,898 deaths and a death rate of 12.2 from the same cause in 1892. The mean annual death rate of the twenty-year period (1874–93) from this cause was 11.1. The maximum death rate of the twenty years was 15.8 in 1875, and

the minimum was 7.7 in 1879. The birth rate of the same year was also the least birth rate of the whole period of registration.

Sex. — The deaths of males from cholera infantum in 1893 were 1,423 and those of females were 1,281. For the whole period (1861–93) the death rates of the sexes were for males 12.3 per 10,000 and for females 10.0 of the living population at all ages.

Since the mortality from this disease affects appreciably only the age period 0–5 years, the factors employed for comparison should be the numbers of each sex in the first years of life, in which age the sex distribution is more uniform than that of the general population. Employing, therefore, this distribution, the death rate of the sexes for cholera infantum is found to be as 112 males to each 100 females in equal numbers living.

Seasons of the Year. — Of the whole number of deaths from cholera infantum in 1893, 2,395, or 88.6 per cent., occurred in the months of July, August and September. In neither of the six spring and winter months did the deaths from the same cause exceed 20. Upon a monthly standard of 100 the highest mortality (459.2) for the thirty-three-year period (1861–93) occurred in August, and the least (4.9) in February.

Age. — Nearly the entire mortality from this disease occurred in the first period of life (0–5 years), both for the year 1893 and for the thirty-three-year period (1861–93). The death rate per 10,000 of the same age for the whole period was 106.5. A better estimate may be found on a later page for single years of life for a seven year period.

Consumption.

The facts in regard to this disease will be treated more in detail in this summary than those which relate to other diseases, for two reasons: first, it is the most prominent and destructive cause of death; second, a widespread interest in this disease has been created by the discussions relating to the prevalence of tuberculosis among cattle.

The whole number of deaths registered as from consumption (of the lungs) for the period of registration (1842–93) was 243,006.

The following tables present the number of deaths, together with the death rate per 10,000 of the population, the percentage of the deaths from all causes for each year, and the mean death rate of five-year periods from 1851 to 1893 (forty-three years).*

* The figures for years previous to 1851 are defective, the returns of several cities and towns being omitted.

From this table and diagram it appears that there has been a progressive and quite uniform decrease in the death rate from consumption in Massachusetts for nearly the whole period, the maximum and minimum death rates being 42.7 per 10,000 of the population in 1853 and 22.7 in 1893, the last year of the period. The figures for the five-year periods were as follows : —

TABLE 29. — *Death Rate from Consumption in Massachusetts, 1851–93, in Five-year Periods.*

1851–55, . .	41.1	1866–70, . .	33.4	1881–85, . .	31.4
1856–60, . .	38.9	1871–75, . .	34.6	1886–90, . .	27.3
1861–65, . .	36.5	1876–80, . .	31.0	1891–93, . .	23.6

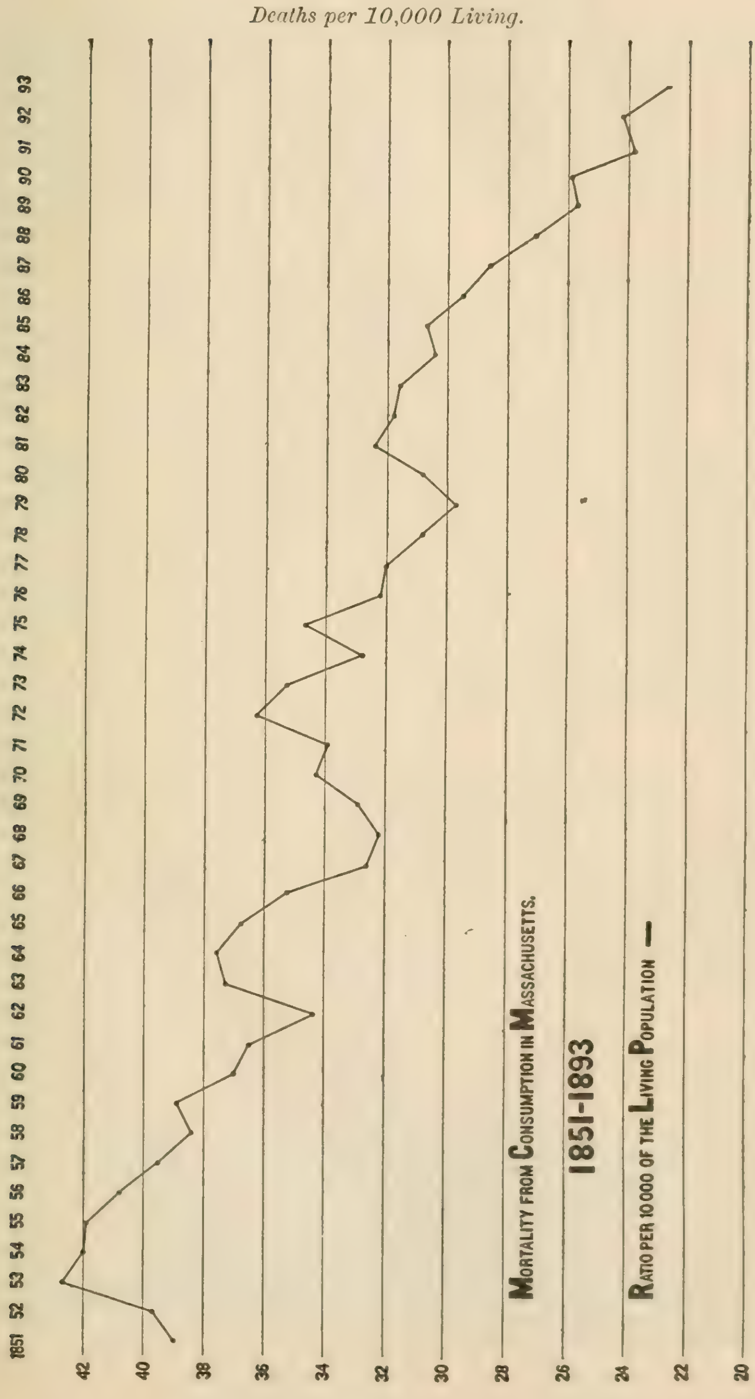

Deaths per 10,000 Living.
Mortality from Consumption in Massachusetts.
1851-1893
Ratio per 10000 of the Living Population —
1851 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93
42 40 38 36 34 32 30 28 26 24 22 20

TABLE 30.— *Consumption.*

Years.	Deaths.	Death Rate per 10,000 Living.	Average Death Rate per 10,000 Living, Five-year Periods.	Percentage of Total Mortality.
1851,	3,982	39.0	41.1	21.03
1852,	4,155	39.7		22.48
1853,	4,593	42.7		22.62
1854,	4,611	41.8		21.53
1855,	4,750	41.9		22.84
1856,	4,701	40.8	38.9	22.67
1857,	4,625	39.5		21.73
1858,	4,574	38.4		22.02
1859,	4,704	38.9		22.43
1860,	4,557	37.0		19.76
1861,	4,522	36.5	36.5	18.78
1862,	4,269	34.3		18.58
1863,	4,667	37.3		16.82
1864,	4,733	37.6		16.46
1865,	4,661	36.8		17.82
1866,	4,600	35.3	33.4	19.46
1867,	4,362	32.6		19.15
1868,	4,437	32.2		17.33
1869,	4,659	32.9		17.88
1870,	5,003	34.3		18.30
1871,	5,070	33.9	34.6	18.14
1872,	5,556	36.3		15.87
1873,	5,556	35.3		16.38
1874,	5,284	32.8		16.57
1875,	5,738	34.7		16.40
1876,	5,327	32.2	31.0	16.05
1877,	5,457	32.0		17.41
1878,	5,334	30.8		17.04
1879,	5,223	29.7		16.42
1880,	5,494	30.8		15.57
1881,	5,886	32.4	31.4	16.14
1882,	5,865	31.8		15.93
1883,	5,931	31.6		15.71
1884,	5,798	30.4		15.67
1885,	5,955	30.7		15.63
1886,	5,897	29.5	27.3	15.83
1887,	5,871	28.6		14.40
1888,	5,728	27.1		13.61
1889,	5,581	25.7		13.36
1890,	5,791	25.9		13.31
1891,	5,484	23.8	23.6	12.14
1892,	5,739	24.2		11.77
1893,	5,527	22.7		11.25

Sex and Age.— As a matter of convenience, these two conditions, sex and age, will be considered together with reference to the mortality from consumption.

The deaths of males from consumption in 1893 were 2,627 and those of females were 2,900. For the period of thirty-three years (1861–93) the death rate of males was 29.1 per 10,000 and that of females was 32.3 per 10,000, or as 90 males to 100 females in equal numbers living. This difference in the death rate of the sexes has diminished, since the deaths for the seven years 1887–93 show that the death rate of males was as 95 to each 100 females in equal numbers living.

The death rate of the two sexes from consumption at each age period is presented in Table 31, wherein it appears that the death rate of females is greater at each age up to the period 30–40, when the death rate of the two sexes is equal, and from that time onward to the close of life the death rate of males is the greater.

The relative difference between the death rate of males and that of females is greatest at the age period 10–15, when the death rate of females from consumption is three times as great as that of males. In the next period (15–20) the death rate of females still remains the greater by more than 50 per cent. In the age period 50–60, on the other hand, the death rate of males becomes the greater by nearly 50 per cent. (These statistics embrace 39,721 deaths, and cover the period of seven years, the census figures of 1890 being used here as the basis of comparison, that year being the mid-year of the period.)

The figures in the last column of this seven-year table may be compared with those of the thirty-three-year table (Table 27). Comparing the long period of thirty-three years with the short or closing period of seven years, it appears that the decrease in the death rate from consumption has taken place at every period of life, but the greatest relative decrease was in the ages from 60 onward to the close of life, and the least was in the period 10–15 years.

Mortality from Consumption, by Sex and Ages, Massachusetts.

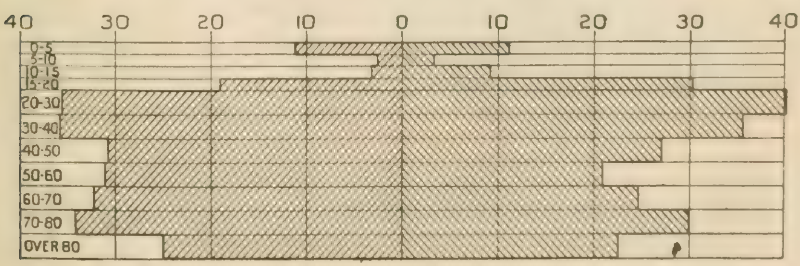
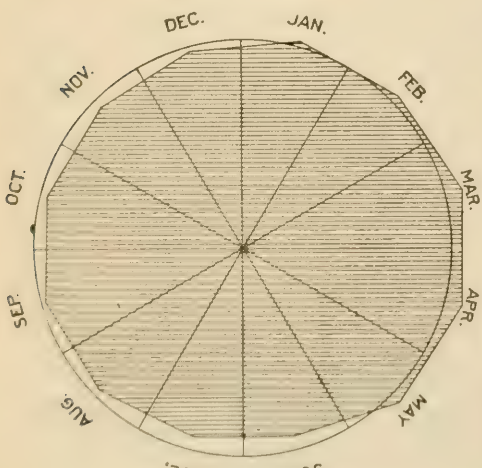


TABLE 31.—*Mortality from Consumption, by Age and Sex, 1887–93.*

Ages.	1887-93. Deaths from Consumption.	1887-93.		Death Rate from Consumption per 10,000 of the Population living at each Age Period for each Sex. 1887-93.		
		Males.	Females.	Males.	Females.	Totals.
Under 5, . .	1,715	861	854	11.2	11.3	11.3
5 to 10, . .	376	158	218	2.3	3.2	2.7
10 to 15, . .	808	202	606	3.0	9.1	6.0
15 to 20, . .	3,722	1,379	2,343	18.9	30.3	24.8
20 to 30, . .	12,339	5,492	6,847	35.4	40.1	37.9
30 to 40, . .	8,557	4,212	4,345	35.8	35.8	35.8
40 to 50, . .	5,119	2,643	2,476	30.7	27.2	28.9
50 to 60, . .	3,204	1,815	1,389	30.9	21.0	25.7
60 to 70, .	2,261	1,203	1,058	32.1	24.9	28.3
70 to 80, . .	1,248	609	639	34.1	30.1	31.9
Over 80, .	294	121	173	24.9	22.6	23.5
Ages not stated, .	78	34	44	-	-	-
Totals, .	39,721	18,729	20,992	-	-	-
Mean, . .	-	-	-	24.6	26.0	25.3

Seasons of the Year.—The comparative uniformity in the mortality rate from consumption throughout the year makes it especially necessary to eliminate the inequality in the lengths of the months, if exactness in comparison is sought. As an example, the least number of deaths from consumption in any month in 1893 was 414 in February; but, if the relative intensity is desired, the deaths in equal periods of time were greater in February than those of any other month except January, March, April and May. This appears also to be true of the long period of thirty-three years (1861–93). Upon a monthly standard of 100 the

Mortality from Consumption, by Months, Massachusetts.



monthly departures from the mean were as follows for the thirty-three-year period : —

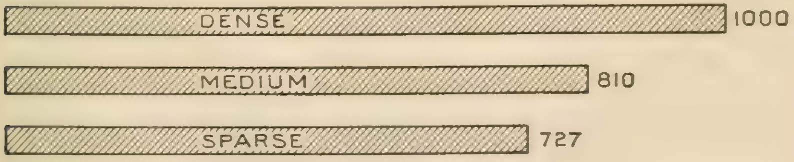
In January,	+2.4	In July,	—6.5
February,	+4.0	August,	—2.9
March,	+8.3	September,	—1.9
April,	+8.6	October,	—3.6
May,	+5.5	November,	—4.5
June,	—6.7	December,	—2.7

Density of Population. — The effect of density of population upon the mortality from consumption is shown by the following figures, in which the mortality of dense districts is assumed to be 1,000 : —

Mortality from consumption in *dense* districts,	1,000
Mortality from consumption in *medium* districts,	810
Mortality from consumption in *sparse* districts,	727

In using the foregoing terms, the word *dense* applies to districts having less than one acre to each inhabitant, *medium* applies to those districts in which there was more than one acre but less than four acres to each inhabitant, and *sparse* applies to those districts in which there were more than four acres to each inhabitant.

The data in the foregoing paragraph were compiled from a total of 112,604 deaths from consumption.



Geographical Distribution. — The following statement is taken from a paper on the "Geographical Distribution of certain Causes of Death in Massachusetts," in the twenty-third annual report of the State Board of Health, 1891 : —

It appears that the mortality from phthisis in Massachusetts diminishes in its ratio to the distance from the sea-coast. Dividing the State counties into the following groups, the mortality from phthisis was as follows : —

GROUPS.	Annual Ratio of Mortality from Phthisis per 10,000 of Population.
1. All of the sea-coast counties except Suffolk,	31.1
2. Worcester County,	27.9
3. The Connecticut River counties,	27.5
4. Berkshire County,	23.7

Nantucket, at the extreme east, and with an insular climate, had a ratio of 45.3. I have excepted Suffolk County from the foregoing list, for the reason that its excessive density of population and the existence in Boston of several large hospitals and places where consumptives are received as patients may be considered as having much greater influence than geographical position upon the phthisis death rate. Admitting Suffolk County to the list, with its mortality ratio of 38.1, the mortality rate of the group thus constituted would be 33.1.

If we assume the mortality from phthisis in the western county (Berkshire) as 1,000, that of the Connecticut valley counties was 1,160; that of Worcester County was 1,177; that of the sea-coast counties (except Suffolk) was 1,312; that of Suffolk was 1,608; that of Nantucket was 1,911.

A similar observation was made by Dr. H. I. Bowditch, in his paper entitled "Consumption in Massachusetts," and at a later date it was also very clearly shown by Dr. W. Everett Smith, in another paper before the Massachusetts Medical Society in 1888.

Classification by Towns.

In examining the list of cities and towns, the 10 towns having the lowest ratios upon the list are all small towns, having an average population in each of but 828. Three only had more than 1,000 inhabitants in each. Four of the number are Berkshire towns. New Ashford, lowest in rank, is a small town of 203 inhabitants (census of 1880), upon very high land, south-west of Mt. Greylock, the highest land in the State. It has a population devoted almost exclusively to farming. Dunstable, Littleton and Burlington are three farming towns of small population, situated in northern Middlesex, and not far apart. Their inhabited portions are mostly high and dry. Nahant, Revere and Winthrop are three nearly contiguous towns upon the sea-coast, each having a resident and transient summer population of considerable size, in addition to the permanent population.

Of the 32 towns in Berkshire, 7 held positions more than fifty per cent. lower than the average of the State in their mortality from consumption, and only 1 of the number, the small town of Alford, had a death rate from this cause which was higher than that of the State.

There was not one town in the State in which there was no death from consumption in the twenty years, and the number of deaths ranged from 2 only in New Ashford up to 28,666 in Boston.

The first city to appear in the list is Newton, ranking as 60 (the State being 100), and followed by other cities in the following order: —

Newton,	60	Chelsea,	92	Salem,	103
Pittsfield,	75	Holyoke,	92	Lynn,	104
Gloucester,	82	Woburn,	93	New Bedford,	105
Quincy,	82	Taunton,	94	Fall River,	107
Fitchburg,	83	Brockton,	94	Chicopee,	113
Malden,	86	Cambridge,	94	Lowell,	114
Springfield,	89	Marlborough,	96	Newburyport,	114
Somerville,	89	Northampton,	97	Lawrence,	122
Worcester,	90	Haverhill,	98	Boston,	127
Waltham,	91	THE STATE,	100		

At the other extreme, the two small Indian towns of Gay Head and Mashpee only had phthisis death rates more than fifty per cent. higher than the average.

Out of the 14 towns of which Barnstable County was comprised at the beginning of the period (1871–90), 9 are to be found among those having a mortality rate from phthisis as great as or greater than that of the State at large.

Of the 58 cities and towns which had high ratios (higher than those of the State), 36 were in the sea-coast and island counties of Essex, Suffolk, Norfolk, Bristol, Plymouth, Barnstable, Dukes and Nantucket. These 36 towns contained over 85 per cent. of the population of the group of 58. Nineteen out of this number are situated immediately upon the sea-coast.

The only cities and large towns having high ratios of mortality from phthisis, and also located at a considerable distance from the sea-coast, are Lowell, Chicopee, Ware and Milford.

A similar tabulation was made in 1865 by Dr. George Derby, afterward secretary of the State Board of Health. This table included a period of ten years, none of which were within the time of the present inquiry. These were the ten years 1856–65.

From his published list of towns having high and low mortality from consumption we find that 13 towns in the list of low mortality are west of the Connecticut River. Twenty-three out of the 25 continued to have low or comparatively low ratios in the later period, and among these Nahant, Weston, Richmond and New Ashford retained positions quite near the minimum in both periods.

In the lists of towns having high mortality from consumption the names of Randolph, Chatham and Orleans appear in both groups, while Fall River, Ware and Rockport appear in the former list, and also have comparatively high positions in the later list. The two small towns of Wales and Oakham show a very marked improvement, having been the ninth and tenth in point of high mortality in the earlier list, while in the later list (1871–90) Wales appears among the 20 towns having lowest mortality, and Oakham has a comparatively low position. The towns of Upton, Northfield, Russell, Salisbury, Millbury, Royalston, Tyngsborough, Enfield, Chesterfield, West Newbury, Ashby, Pepperell and Lunenburg changed their position from a high to a comparatively low rank.

Among the cities, Newton maintains a very low rank in each table, and Holyoke, which was a small town in the earlier period, was lowest in the earlier list but has an intermediate place in the later table.

In the earlier table Fall River was the only city among the 20 places having the highest mortality from phthisis, but in the later list Boston appears among the 20 highest as the city having highest ratio of mortality from phthisis; while Lawrence, Newburyport, Lowell and Chicopee follow in the order named, and Fall River takes a lower position than either of these.

Another condition favorable to the development of phthisis is location at a low level as compared with the level of the sea. Berkshire, Franklin and the other western counties, having low ratios of mortality from this cause, are all at elevations much higher than the sea-coast counties.

Further and more detailed information relative to the mortality from consumption in each city and town in the State may be found in the twenty-third annual report of the Board, already mentioned, pages 844–855.

Pneumonia.

The deaths from pneumonia in the State in 1893 were 5,499 and the death rate per 10,000 of the population was 22.6, as compared with a death rate of 21.2 in 1892. There has been an increase in the mortality, comparing the first years of the twenty-year period (1874–93) with the closing years of the period. The mean death rate of the period was 16.6. The minimum death rate from this cause was 11.6 in 1877 and the maximum was 22.6 in 1893.

Sex. — The death rate of males was greater than that of females, being, for the period of thirty-three years, ending with 1893, 16.1 per 10,000 living males and 14.4 per 10,000 females, or as 112 males to each 100 females in equal numbers living.

Seasons of the Year. — The greatest mortality from this cause in 1893 was in the months of April and December, and the least in August and September. For the whole period of thirty-three years (1861–93), and upon a mean monthly standard of 100, the greatest mortality was in January (160.9) and March (157.0), and the least was in August (33.5) and July (41.4).

Age. — The mortality at different ages from pneumonia for 1893 is shown in Table 28, wherein the greatest absolute number of deaths is found to have occurred in the age period 0–5 years and the least in the period 10–15 years. But these figures have little significance when compared with the relative death rates shown in Table 27 for the thirty-three-year period ending with 1893. By this table it appears that the highest mortality from pneumonia was at the period 80 years and over, wherein it was 131.7 per 10,000 living of that age. The next highest death rate (74.6 per 10,000) was at the period 70–80 years, and the next (45.2) at the earliest period of life, 0–5 years. The death rates of the four periods of life 50–60, 60–70, 70–80 and all over 80, from this cause, increase at very nearly a geometric ratio.

Dysentery.

The whole number of deaths from dysentery in 1893 was 231, and the death rate 0.95 per 10,000, as compared with 0.81 in 1892. Compare whole period.

Sex. — For the single year 1893 the deaths of females were considerably greater in number than those of males, being 134 of the former to 97 of the latter. But for the thirty-three-year period ending with 1893 the death rates of males and females were nearly equal, the mean annual death rate of males being 2.88 per 10,000 and those of females 2.82, or in the ratio of 102 males to each 100 females in equal numbers living.

Seasons of the Year. — The deaths from this cause in the six winter and spring months of 1893, as well as in the same months of the thirty-three-year period, were comparatively small. Upon a mean monthly standard of 100 the deaths from this cause in these six months did not exceed 18.1, while the highest mortality, according to the same standard, was in the months of August and September (402.4 and 324.6).

Age. — The highest death rate from this cause for the whole series of thirty-three years was at the old-age period, over 80 years, in which it was 25.9 per 10,000, and the next highest was 13.6 per 10,000 and at the other extreme of life (0–5 years). The mean annual death rate of each of the age periods from 10 to 40 years was less than one per 10,000 living, and that of the next period (40–50) was but little more than one per 10,000.

Whooping-cough, Cancer, Kidney Diseases, Heart Diseases and Brain Diseases.

The figures for these causes of death embrace only the absolute numbers for each of the twenty years 1874–93, together with the gross death rates and percentages of the total mortality. The subject of whooping-cough will be treated more in detail at a later part of the general report of the Board.

Whooping-cough. — The deaths from this cause in 1893 were 274 and the death rate 1.1, as compared with 1.0 in 1892 and an annual mean of 1.4 for the twenty-year period (1874–93).

Cancer. — The deaths from cancer in 1893 were 1,533 and the death rate was 6.3 per 10,000, as compared with 5.9 in 1892. The mean annual death rate of the twenty-year period from this cause was 5.3 per 10,000. The maximum death rate was that of 1893, 6.3, and the minimum was 3.5 in 1875. The death rate from this cause has increased with considerable uniformity from 3.6 in 1874 to 6.3 in 1893. For the twenty years ending with 1893 the deaths of females from this cause have constituted more than 70 per cent. of the total mortality from cancer.

Kidney Diseases. — The number of deaths from kidney diseases in 1893 was 1,685 and the death rate 6.9 per 10,000 of the population, as compared with a death rate of 6.5 in 1892 and a mean annual death rate for the twenty-year period 1874–93 of 5.0. The maximum death rate from this cause was 6.9 in the last year of the twenty-year period, and the minimum (2.9) was in the first and third years, 1874 and 1876.

The deaths at different ages from kidney diseases show that the relative mortality is fairly uniform for the first ages of life up to 30 years of age, except the period 5 to 10 years, which is less than half that of either of the other early periods of life. After 30

years it increases rapidly up to the close of life, being, for the period 80 years and over, more than fifty-fold as great as at age 5–10.

Heart Diseases. — The number of deaths from this group of causes in 1893 was 3,511 and the death rate was 14.4 per 10,000 of the population, as compared with a death rate of 15.7 from the same causes in 1892 and a mean annual death rate of 11.8 for the twenty-year period. The maximum death rate of the period was 15.7 in 1892 and the minimum was 7.9 in 1874 and 1877.

The deaths from heart diseases were for the census years 1850–90 from three to four times as great in the period 0–5 years as for either of the following periods up to 30 years, and then increased rapidly up to the close of life.

Brain Diseases. — Under this title are grouped the deaths registered as from apoplexy, paralysis, cephalitis, insanity, softening of the brain and the general term brain disease.

The number of deaths from this group of causes for 1893 was 5,144 and the death rate was 21.1 per 10,000 of the estimated population, as compared with a death rate from the same causes of 21.2 in 1892 and a mean annual death rate of 18.7 for the twenty-year period. The maximum death rate from the same causes was 21.2 in 1892 and the minimum was 14.8 in 1877.

Erysipelas. — The deaths from erysipelas in 1893 were 251, or 1 per 10,000 of the population. The deaths from puerperal fever were 46, or less than .2 per 10,000 of the population. The deaths from other incidents of childbirth were 235, or .9 per 10,000 of the population.

Certain Infectious and Communicable Diseases not Ordinarily very Destructive to Large Numbers of People, including Certain Diseases caused by Infection from the Lower Animals.

Malarial Fevers. — The number of deaths registered as due to ague and remittent fever was 86, of which number 48 were males and 38 were females. The greatest number in any month (12) occurred in May and the least (4) in January. Nine were under 5 years and 53 were between 20 and 70 years.

The deaths from these causes for the ten years ending with 1893 were as follows: —

Years.	Deaths from Malarial Fever.	Years.	Deaths from Malarial Fever.
1884,	31	1889,	77
1885,	56	1890,	60
1886,	32	1891,	62
1887,	46	1892,	81
1888,	64	1893,	86

The fatality from this disease does not appear to be very great, considering the unusually large number of cases which are known, by the investigations of the Board, to have existed in eastern Massachusetts during the past ten years.

Syphilis. — The deaths from this cause registered in 1893 were 48, of which 25, or more than half, occurred in Suffolk County. Of this number, 34, or more than 70 per cent., were probably congenital, being those of infants, mostly under 1 year of age.

Hydrophobia, Glanders and Anthrax. — There were only two deaths from hydrophobia in 1893.

The deaths for the past ten years from this cause were as follows: —

1884,	0	1889,	14
1885,	0	1890,	17
1886,	0	1891,	9
1887,	0	1892,	1
1888,	2	1893,	2

There was one death from glanders and one from anthrax or malignant pustule in 1893.

Trichinosis. — No deaths from trichinosis were reported in 1893. Five deaths from this cause are known to have occurred in the previous year, but no reference to them is to be found in the Registration Report of that year.

The following table is introduced for the purpose of affording an opportunity of comparing the statistics of Massachusetts with those of two large nations having thorough systems of registration: —

TABLE 32.— *Mortality from Different Causes in Massachusetts (1892 and 1893), and in England and the German Empire (1892).*

[Expressed as a ratio per 10,000 of the living population.]

CAUSES OF DEATH.	MASSACHUSETTS.		England.	German Empire.
	1892.	1893.	1892.	1892.
Measles,	.4	1.1	4.63	3.10
Small-pox,	.01	.04	.15	.02
Scarlet-fever,	2.8	3.3	1.90	2.21
Diphtheria and croup,	6.1	5.7	2.98	11.83
Whooping-cough,	1.0	1.1	4.55	3.98
Typhoid fever,	3.5	3.1	1.37	1.75
Phthisis, pulmonary,	24.2	22.7	14.68	23.50
Other forms of tubercular disease,	7.1	7.6	4.26	1.70
Pneumonia,	21.2	22.6	12.51	14.82
Cancer,	5.9	6.3	6.90	6.10
Puerperal fever,	.3	.2	.80	.69
Other accidents of childbirth,	.9	1.0	.97	.87
Old age,	8.0	7.6	9.44	23.30
Accident or negligence,	7.7	8.0	5.53	3.78
Suicide,	1.2	1.2	.88	2.05
Hydrophobia,*	–	–	–	–

* Ratios inappreciable: 1 death in Massachusetts in 1892, 2 in 1893, 6 in England in 1892, and 4 in Germany.

Deaths at Early Ages, from Certain Causes.

In the summaries of the vital statistics of Massachusetts which have been hitherto presented, the deaths and death rates of children have only been stated for the first ten years of life in two groups of five years each, 0–5 and 5–10. It is desirable to present a finer division for the first years of life, by single years, a practice which is now followed in nearly all countries having registration.

The causes of death selected for presentation in the following table are the principal infectious diseases of infancy and childhood, together with dysentery, pneumonia and bronchitis, which present their highest death rates at the two extremes of infancy and old age.

The figures for the group 5–10 years are added for the purpose of comparison.

In the preparation of this table the figures employed are those of the seven years 1887–93. These were selected for the reason that the division by single years for the first five years was introduced into the Registration Report in 1887, and for this period the mid-year 1890 was a census year, and may be very conveniently employed as a basis for calculating the mean death rates. The corrected figures, in which the omissions and faults of distribution of the census are adjusted, are employed in preparing this table.

TABLE 33. — *Mortality from Certain Diseases of Children, by Ages. — Seven Years (1887–93).*

AGE PERIODS.	Measles.	Scarlet-fever.	Diphtheria.	Croup.	Whooping-cough.	Cerebro-spinal Meningitis.	Cholera Infantum.	Dysentery.	Pneumonia.	Bronchitis.
0-1, . . .	429	214	415	442	1,132	257	14,785	298	4,120	3,619
1-2, . . .	517	445	1,036	626	408	114	2,160	149	1,981	1,158
2-3, . . .	192	516	1,215	601	160	82	264	47	855	363
3-4, . . .	98	462	1,169	418	92	59	76	38	454	197
4-5, . . .	67	373	1,004	282	44	34	42	21	342	93
0-5, . . .	1,303	2,010	4,839	2,369	1,836	546	17,327	553	7,752	5,430
5-10, . . .	122	831	2,506	478	52	109	7	57	691	166

Average Annual Mortality at Each Age Period, compared with the Population living at Each Period, expressed as a Ratio per 10,000 of such Living Population (1887–93).

AGE PERIODS.	Measles.	Scarlet-fever.	Diphtheria.	Croup.	Whooping-cough.	Cerebro-spinal Meningitis.	Cholera Infantum.	Dysentery.	Pneumonia.	Bronchitis.
0-1, . . .	12.8	6.4	12.4	13.2	33.7	7.6	440.0	8.9	122.6	107.7
1-2, . . .	16.1	13.9	32.3	19.5	12.7	3.6	67.3	4.6	61.7	36.1
2-3, . . .	6.1	16.4	38.7	19.2	5.1	2.6	8.4	1.5	27.3	11.6
3-4, . . .	3.2	15.0	37.8	13.5	3.0	1.9	2.5	1.2	14.7	6.4
4-5, . . .	2.2	12.2	32.9	9.2	1.4	1.1	1.4	.7	11.2	3.0
0-5, . . .	8.2	12.7	30.5	14.9	11.6	3.4	109.3	3.5	48.9	34.3
5-10, . . .	.9	6.1	18.3	3.5	.4	.8	.0	.4	5.0	1.2

By this table it appears that the death rate from *measles*, 16.1 per 10,000 of those living at the same year of life, is highest in the second year 1–2, that of the first year being a little less, while there is a rapid fall in the death rate from 16.1 in the second year to 2.2 in the fifth.

In *scarlet-fever* the highest mortality is not reached till the third year of life, when it is nearly three times as great as that of the first year. That of the fifth year (12.2) is also nearly double that of the first year.

In *diphtheria* the highest death rates are found in the third and fourth years of life, in which they are nearly equal, and more than three times as great as that of the first year, while the second and fifth years are nearly equal and intermediate between the first and third.

In *croup* the death rates of the second and third years are nearly equal, and about 50 per cent. higher, than that of the first year, which is also nearly the same as that of the fourth year of life.

In *whooping-cough* the death rate of the first year of life is far greater than that of either of the succeeding years, the death rate rapidly diminishing from 33.7 per 10,000 living in the first year to 1.4 in the fifth year of life, and only .4 in the period 5–10 years.

In *cerebro-spinal meningitis* the mortality diminishes steadily from 7.6 in the first year to 1.1 in the fifth and .8 in the period 5–10 years.

In *cholera infantum* the intensity of the disease is mostly expended upon the first year of life, the death rate of the second year being less than one-sixth as great as that of the first, while those of the third, fourth and fifth years become comparatively insignificant. The 7 deaths registered in the period 5–10 years cannot be expressed by a single decimal figure, and may be accounted for by possible errors.

In *dysentery* the death rate decreases rapidly from 8.9 in the first year to .7 in the fifth.

In *pneumonia*, as well as in *bronchitis*, the death rates are high in the first year of infancy, being respectively 122.6 and 107.7 for the two diseases, and diminishing from these high rates to 11.2 and 3.0 respectively in the fifth year. In each of these causes of death the death rates also increased rapidly in the last age periods of extreme old age, that of pneumonia being shown in Table 27.

The Vital Statistics of the Urban Population.

The population of the cities and large towns of Massachusetts has increased with much greater rapidity than that of the rural districts, and demands increasing attention in any general presentation of the vital statistics of the State. In the fifty years of registration in Massachusetts the population of towns and cities having more than 10,000 inhabitants in each has increased from 24 per cent. of the total population of the State to more than 61 per cent.

In the forty-ninth Registration Report (1890) a table was introduced in which the marriage, birth and death rates of the 28 cities were presented. In the present summary a similar table is presented, amplified and made to include the statistics of all towns having over 10,000 inhabitants in each (37 in number) for the period of three years, 1891, 1892 and 1893, and also the deaths and death rates from seven principal infectious and other causes of death. The marriage, birth and death rates are estimated from a mean estimated population for 1892, as a mid-year mean of the triennial period 1891–93. The statistics are also presented for the urban district as a whole, for the rural district as a whole, for the State as a whole, and also for each of four groups of cities, arranged according to their populations.

This table illustrates clearly the effect of density of population upon mortality rates, as demonstrated by Dr. Farr. The density of population in this table is measured in terms of the number of acres to each inhabitant, and is necessarily approximate, since the area is quoted from the report of the tax commissioner, which includes assessed acres only, excluding the area of public lands, highways, etc. By this estimate the density of the State for the period in question was 1.9 acres to each inhabitant. That of the district groups was as follows: —

Density of Population, Massachusetts, 1891–93.

	Acres to Each Inhabitant.
The State,	1.9
Cities and towns composing the urban districts,	.2
Towns composing the rural districts,	5.3
Group I., the city of Boston,	.04
Group II., cities having from 50,000 to 100,000 population in each,	.13
Group III., cities having from 25,000 to 50,000 in each,	.29
Group IV., cities having from 10,000 to 25,000 in each,	.61

For convenience of comparison, a standard of 1,000 for the State is here adopted, and the condensed table is as follows : —

TABLE 34. — *Death Rates from Certain Diseases; the State = 1,000.*

	Density, Acres per Inhabitant.	Marriage Rate.	Birth Rate.	Death Rate.	Death Rate from Phthisis.	Death Rate from Pneumonia.	Death Rate from Typhoid Fever.	Death Rate from Diphtheria and Croup.	Death Rate from Measles.	Death Rate from Scarlet-fever.	Death Rate from Cholera Infantum.
THE STATE, ...	1.9	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Urban districts, . . .	.2	1,088	1,104	1,036	1,064	1,044	1,053	1,110	1,083	1,173	1,158
Rural districts, . . .	5.3	823	790	927	870	912	893	778	845	646	681
Group I., urban district, .	.04	1,183	1,126	1,163	1,345	1,287	887	1,629	1,179	1,658	991
Group II., " " .	.13	1,091	1,117	1,067	1,005	984	1,142	832	1,238	881	1,655
Group III., " " .	.29	1,068	1,094	971	912	959	1,157	974	976	1,074	1,068
Group IV., " " .	.61	936	1,064	867	905	833	1,030	806	857	888	856

This table shows very clearly the effect of density of population in modifying the general death rate. The mortality increases coincidently with the density. The same effect is shown in the columns for different diseases, except that here the peculiar characteristics of each disease show their further modifying influence in increasing or diminishing and in some instances entirely outweighing the effect of density.

In groups II. and III. of the urban districts the typhoid death rate was highest, since the two cities of Lowell and Lawrence, having during the greater part of this period polluted water supplies, are included.

The high mortality of Boston (District I.) from diphtheria and from scarlet-fever and its low death rate from cholera infantum are notable.

The death rate of Lowell and Fall River from cholera infantum raised the figures of District II. excessively.

TABLE 35. — *Population, Marriages, Births, Deaths and Death Rates from Certain Diseases in Three Years, 1891, 1892 and 1893, in Cities and Towns having over 10,000 Inhabitants, in Massachusetts.*

[The marriage, birth and general death rates are expressed as a ratio per 1,000, and those of certain diseases as a ratio per 10,000, of the living population.]

Number.	CITIES.	Population, 1890.	Estimated Mean Population, 1891-93.	Marriages.	Marriage Rate, Persons Married.	Births.	Birth Rate.	Deaths.	Death Rate.	Deaths from Consumption.	Death Rate.
1	Boston,	448,477	474,062	15,854	22.29	44,126	31.03	33,273	23.40	4,505	31.68
2	Worcester,	84,655	92,196	2,609	18.86	8,706	31.48	5,309	19.19	592	21.40
3	Lowell,	77,696	83,906	2,851	22.65	7,648	30.38	6,312	25.07	665	26.42
4	Fall River,	74,398	82,837	2,584	20.80	7,860	31.63	5,948	23.94	520	20.92
5	Cambridge,	70,028	74,664	2,164	19.32	7,170	32.01	4,625	20.65	662	29.56
6	Lynn,	55,727	60,242	1,940	21.47	4,995	27.64	3,149	17.42	357	19.75
7	Lawrence,	44,654	47,204	1,630	23.02	4,268	30.14	3,559	25.14	299	21.12
8	Springfield,	44,179	47,133	1,359	19.22	4,213	29.80	2,841	20.09	325	22.98
9	New Bedford,	40,733	44,098	1,552	23.46	4,576	34.59	3,090	23.36	339	25.62
10	Somerville,	40,152	45,131	1,236	18.25	3,930	29.02	2,300	16.98	278	20.53
11	Holyoke,	35,637	39,303	1,195	20.27	5,025	42.62	2,412	20.45	245	20.78
12	Salem,	30,801	31,956	851	17.75	2,700	28.16	2,012	20.98	213	22.22
13	Chelsea,	27,909	28,842	998	23.06	2,645	30.56	1,960	22.64	245	28.31
14	Haverhill,	27,412	30,042	933	20.70	2,418	26.83	1,580	17.53	209	23.18
15	Brockton,	27,294	30,436	879	19.25	2,168	23.74	1,302	14.26	157	17.20
16	Taunton,	25,448	26,190	680	17.30	2,194	27.92	1,615	20.55	166	21.11
17	Gloucester,	24,651	25,938	714	18.35	1,898	24.39	1,294	16.63	145	18.63
18	Newton,	24,379	26,514	763	19.18	1,912	24.03	1,189	14.94	144	18.10
19	Malden,	23,031	26,377	772	19.51	2,276	28.76	1,335	16.87	160	20.21
20	Fitchburg,	22,037	25,446	765	20.04	2,743	35.93	1,311	17.17	147	19.25

21	Waltham,	18,707	20,355	660	21.61	1,674	27.41	965	15.80	163	26.69
22	Pittsfield,	17,281	18,407	424	15.35	1,636	29.62	930	16.84	97	17.56
23	Quincy,	16,723	18,555	477	17.13	1,978	35.53	929	16.68	151	27.12
24	North Adams,	16,074	17,488	445	16.96	1,907	36.35	1,022	19.48	109	20.77
25	Northampton,	14,990	15,828	394	16.59	1,105	23.27	803	16.90	101	21.27
26	Chicopee,	14,050	15,064	646	28.58	1,681	37.19	1,099	24.33	112	24.78
27	Newburyport,	13,947	14,039	421	19.99	954	22.65	948	22.51	115	27.30
28	Marlborough,	13,805	14,951	324	14.44	1,369	30.51	684	15.24	102	22.73
29	Woburn,	13,499	14,199	306	14.37	1,334	31.31	777	18.24	82	19.24
30	Brookline,	12,103	13,265	364	18.28	1,058	26.58	628	15.78	69	17.34
31	Medford,	11,079	11,893	247	13.84	934	26.17	568	15.92	54	15.13
32	Everett,	11,068	13,166	376	19.03	1,487	37.64	747	18.91	97	24.55
33	Weymouth,	10,866	10,916	254	15.51	707	21.58	571	17.43	77	23.51
34	Beverly,	10,821	11,475	281	16.32	742	21.55	553	16.06	69	20.04
35	Clinton,	10,424	11,016	323	19.54	1,045	31.62	481	14.55	39	11.80
36	Hyde Park,	10,193	10,919	261	15.93	870	26.56	475	14.50	65	19.84
37	Peabody,	10,158	10,410	197	12.61	734	23.50	483	15.46	45	14.41
38	Totals, urban,	. . .	1,584,463	48,729	20.50	144,686	30.44	99,079	20.84	11,920	25.07
39	Totals, rural,	. . .	785,530	18,267	15.50	51,334	21.78	43,952	18.65	4,830	20.50
40	Totals, the State,	2,238,943	2,369,993	66,996	18.84	196,020	27.57	143,031	20.11	16,750	23.55
41	Over 100,000,	. . .	474,062	15,854	22.29	44,126	31.03	33,273	23.40	4,505	31.68
42	Less than 100,000 and over 50,000,	. . .	393,845	12,148	20.56	36,379	30.78	25,343	21.45	2,796	23.66
43	Less than 50,000 and over 25,000,	. . .	474,610	14,327	20.12	42,966	30.17	27,800	19.52	3,072	21.57
44	Less than 25,000,	. . .	241,946	6,400	17.63	21,215	29.23	12,663	17.44	1,547	21.31

TABLE 35. — *Population, Marriages, Births, Deaths and Death Rates from Certain Diseases in Three Years, 1891, 1892 and 1893, in Cities and Towns having over 10,000 Population, in Massachusetts* — Concluded.

Number.	CITIES.	Deaths from Pneumonia.	Death Rate.	Deaths from Typhoid Fever.	Death Rate.	Deaths from Diphtheria and Croup.	Death Rate.	Deaths from Measles.	Death Rate.	Deaths from Scarlet-fever.	Death Rate.	Deaths from Cholera Infantum.	Death Rate.
1	Boston,	3,821	26.87	425	2.99	1,326	9.32	141	.99	573	4.03	1,658	11.66
2	Worcester,	525	18.98	63	2.28	161	5.82	27	.98	37	1.34	375	13.56
3	Lowell,	619	24.59	210	8.34	80	3.17	33	1.31	39	1.55	766	30.43
4	Fall River,	514	20.68	94	3.78	111	4.47	32	1.29	66	2.66	749	30.14
5	Cambridge,	437	19.51	50	2.23	118	5.27	12	.54	90	4.02	234	10.45
6	Lynn,	332	18.37	38	2.10	93	5.15	19	1.05	21	1.16	178	9.85
7	Lawrence,	450	31.78	144	10.17	101	7.13	11	.78	131	9.25	333	23.51
8	Springfield,	266	18.81	72	5.09	97	6.86	19	1.34	49	3.46	168	11.88
9	New Bedford,	257	19.42	53	4.00	35	2.64	8	.60	16	1.21	257	19.42
10	Somerville,	249	18.39	40	2.95	49	3.62	12	.89	35	2.58	133	9.82
11	Holyoke,	241	20.43	51	4.32	135	11.45	29	2.46	26	2.20	194	16.45
12	Salem,	216	22.53	44	4.59	47	4.90	3	.31	5	.52	122	12.72
13	Chelsea,	225	26.00	25	2.89	57	6.59	3	.35	25	2.89	82	9.48
14	Haverhill,	177	19.64	33	3.66	33	3.66	3	.33	12	1.33	84	9.32
15	Brockton,	136	14.89	22	2.41	86	9.42	1	.11	16	1.75	57	6.24
16	Taunton,	164	20.87	19	2.42	29	3.69	2	.25	19	2.42	87	11.07
17	Gloucester,	112	14.39	11	1.41	20	2.57	7	.90	10	1.28	69	8.87
18	Newton,	142	17.84	15	1.89	53	6.66	2	.25	4	.50	41	5.15
19	Malden,	107	13.52	17	2.15	34	4.30	4	.50	22	2.78	52	6.57
20	Fitchburg,	111	14.54	10	1.31	18	2.36	13	1.70	2	.26	111	14.54

21	Waltham,	123	20.14	10	1.64	12	1.96	7	1.14	15	2.46	29	4.75
22	Pittsfield,	113	20.46	16	2.90	25	4.53	5	.90	17	3.07	53	9.59
23	Quincy,	69	12.39	23	4.13	23	4.13	5	.89	8	1.43	46	8.26
24	North Adams,	115	21.92	31	5.91	63	12.01	1	.19	23	4.38	91	17.34
25	Northampton,	99	20.85	11	2.31	23	4.84	6	1.26	10	2.10	45	9.48
26	Chicopee,	115	25.44	43	9.51	15	3.32	3	.66	11	2.43	97	21.46
27	Newburyport,	57	13.53	15	3.56	58	13.77	1	.24	5	1.19	36	8.55
28	Marlborough,	72	16.05	14	3.12	12	2.67	3	.67	4	.89	55	12.25
29	Woburn,	67	15.72	19	4.46	31	7.28	2	.47	16	3.78	38	8.92
30	Brookline,	77	19.34	7	1.76	9	2.26	6	1.51	8	2.00	28	7.03
31	Medford,	50	14.01	11	3.09	11	3.09	1	.28	10	2.80	39	10.93
32	Everett,	80	20.24	9	2.28	20	5.06	6	1.52	18	4.56	36	9.11
33	Weymouth,	44	13.43	12	3.66	8	2.44	–	–	5	1.53	20	6.10
34	Beverly,	37	10.74	6	1.74	3	.87	1	.29	1	.29	19	5.52
35	Clinton,	52	15.73	5	1.51	8	2.41	2	.60	4	1.21	49	14.82
36	Hyde Park,	54	16.48	11	3.36	13	3.97	1	.31	1	.31	21	6.41
37	Peabody,	39	12.48	9	2.88	1	.32	2	.64	1	.32	29	9.28
38	Totals, urban,	10,364	21.80	1,688	3.55	3,018	6.35	433	.91	1,355	2.85	6,481	13.63
39	Totals, rural,	4,492	19.05	710	3.01	1,049	4.45	167	.71	370	1.57	1,890	8.02
40	Totals, the State,	14,856	20.88	2,398	3.37	4,067	5.72	600	.84	1,725	2.43	8,371	11.77
41	Over 100,000,	3,821	26.87	425	2.99	1,326	9.32	141	.99	573	4.03	1,658	11.66
42	Less than 100,000 and over 50,000,	2,427	20.54	455	3.85	563	4.76	123	1.04	253	2.14	2,302	19.48
43	Less than 50,000 and over 25,000,	2,853	20.03	556	3.90	794	5.57	117	.82	372	2.61	1,790	12.57
44	Less than 25,000,	1,263	17.40	252	3.47	335	4.61	52	.72	157	2.16	731	10.07

Medical Examiners' Returns.

The returns of the medical examiners comprise the deaths which were investigated by those officers during the year 1893, this class of deaths being those which were of a violent, sudden, suspicious or doubtful character, and were therefore referred to the medical examiners for their official action.

The whole number of deaths of this class which were investigated during the year was 2,221. Of this number, 76 were reported as deaths from homicide, 290 by suicide, 976 from accident or negligence and 879 from natural or unknown causes, including alcoholism. Of the whole number, 1,678 were males, 530 were females, the sex of 13 was unknown. The number of autopsies conducted was 269.

Comparative Vital Statistics.

The question may be asked, "How does the death rate of Massachusetts compare with that of other States and countries?" and in the last annual report, page xliii, a brief reference was made to the subject of the methods adopted for arriving at a just comparison of mortality statistics, in the following language: —

The crude death rate obtained by estimating the ratio of the number of deaths to the living population has been employed for many years as an index of the sanitary condition of a community, and for comparing its sanitary condition with that of other communities. While this method may be trusted in the comparison of the death rates of a nation, a State, county, city or town at different periods of time (since the age and sex distribution of communities remains fairly constant when comparisons are made for brief periods or successive years), it cannot be trusted for the comparison of different towns, cities, States and countries with each other, when the age and sex distribution differs widely, as, for example, in our own State, in the case of Barnstable and Bristol counties, or Barnstable and Suffolk.

In support of this statement Dr. Farr says: "Independently of other causes of variation, the mortality of different populations will differ according as they consist of numbers in various proportions at the ages at which the mortality is high or low."

"It is not too much to say that death rates calculated on the gross population are practically worthless as evidence of the sanitary conditions of communities less than entire nations." (Dr. E. F. Willoughby, Handbook of Public Health and Demography.)

For the purpose of facilitating the methods of correcting death rates according to age and sex distribution, Dr. Ogle, of the British Registration of Statistics office, and J. Körösi, Director of Statistics of Hungary, have proposed the employment of standards of population in which a normal or standard distribution of ages and sexes is presented. For this purpose Dr. Ogle combines the populations of seven principal European countries, including about one hundred and seventy million inhabitants, and presents a table in which the average distribution of these populations is given by sexes and age periods, the whole number of such periods being twelve. For the purpose of comparison with other countries, States, cities or smaller communities, this method has the disadvantage of requiring an amount of computation which becomes burdensome; and, secondly, the age periods employed above 20 years do not correspond with those which have usually been adopted in Massachusetts and other American communities, and, while there are some advantages in adopting a distribution into the periods 25–35, 35–45, etc., instead of 20–30, 30–40, etc., the differences are so slight as not to make it advisable to change the existing methods.

Körösi of Buda-Pesth suggests a method which is less cumbrous than the foregoing. He does not deem it essential for this purpose to adopt a sex distribution, but employs a distribution of ages only, and divides them into four periods, as follows: —

All under one year.
One to twenty years.
Twenty to fifty years.
All over fifty years.

It is evident that, in order to form a just comparison of our death rate in Massachusetts upon an international basis, the age distribution must necessarily be taken into account, since this age distribution differs materially from that of other countries, in consequence of the marked effect of immigration upon the adult ages of the population.

For the purpose of arriving at an accurate conclusion as to the comparative mortality rate of the population of Massachusetts, the following table is presented, in which the distribution of the population at each census from 1865 to 1890 is given, together with the percentages to the total population for these four age periods: —

TABLE 36.

AGE PERIODS.	1865.		1870.		1875.	
	Population.	Per Cent.	Population.	Per Cent.	Population.	Per Cent.
Under 1,	23,719	1.87	32,987	2.26	34,140	2.08
1-20,	497,478	39.31	554,253	38.04	621,022	37.83
20-50,	553,880	43.76	651,699	44.72	759,481	46.27
Over 50,	190,653	15.06	218,371	14.98	226,967	13.82
	1,265,730	100.00	1,457,310	100.00	1,641,610	100.00
Unknown,	1,302	-	41	-	10,302	-

AGE PERIODS.	1880.		1885.		1890.	
	Population.	Per Cent.	Population.	Per Cent.	Population.	Per Cent.
Under 1,	37,587	2.11	35,888	1.85	43,043	1.93
1-20,	681,788	38.24	726,749	37.42	763,134	34.18
20-50,	803,812	45.08	886,085	45.63	1,060,190	47.49
Over 50,	259,898	14.57	293,275	15.10	366,075	16.40
	1,783,085	100.00	1,941,997	100.00	2,232,442	100.00
Unknown,	0	-	144	-	6,501	-

NOTE. — In this table no correction is made for probable errors or deficiencies.

The foregoing table shows that the age distribution of the population of the State has remained fairly constant for a quarter of a century, the variation being but slight.

The foregoing age periods were adopted by M. Körösi after trials with different periods. They differ somewhat from those which have been in use, but he states that it "was found to be preferable to group the first year separately, and that there was no sensible change produced by placing the next nineteen years in one single group."

These figures were not presented in the summary of last year, since the age distribution of the Massachusetts population in the census year 1890 was not then accessible.

The chief difference in this table as compared with the figures for foreign countries lies in the larger percentage of the third age period, 20–50, which is due to the large number of immigrants of this age. Observations extending over a period of more than a

half-century show that nearly 60 per cent. of the immigrants during that time were between 20 and 50 years of age, while those under 10 years of age constituted only 15 per cent.

Körösi presents the population of Sweden as a standard for comparison, — a country having what may be termed a normal age distribution with a constantly low death rate.

With this standard in view the following table is presented, giving the age distribution of the living and the dead for Massachusetts for the two census years, 1885 and 1890, with mortality indices for the purpose of comparison : —

TABLE 37. — *Comparative Mortality of Massachusetts, 1885, 1890.*

Ages.	The Living, 1885.	The Dead, 1885.	Coefficient, Per 1,000.	Per Cent. of Population, Sweden.	Mortality Index.
0-1 year,	41,140*	7,625	185.3	2.65	4.91
1-20 years,	696,990*	7,547	10.8	39.81	4.31
20-50 years,	894,889	9,443	10.5	38.62	4.07
50 and over,	323,130	13,346	41.3	18.92	8.17
	-	-	-	100.00	21.46

Ages.	The Living, 1890.	The Dead, 1890.	Coefficient, Per 1,000.	Per Cent. of Population, Sweden.	Mortality Index.
0-1 year,	48,000*	9,625	200.5	2.65	5.31
1-20 years,	780,859*	7,585	9.7	39.81	3.86
20-50 years,	1,060,190	10,879	10.3	38.62	3.96
50 and over,	366,075	15,290	41.7	18.92	7.90
	-	-	-	100.00	21.03

* The figures for these age periods 0-1 and 1-20 have been corrected in accordance with the principles explained on a previous page.

With these figures it now becomes possible to compare the mortality of Massachusetts with that of other countries having a different age distribution, each of these being separately referred to the Swedish distribution. For this purpose the last census of those countries is adopted as the source of the figures given.

The following list presents the comparative mortality * of fourteen countries, as compared with that of Massachusetts : —

* Mortalitäts Coefficient u. Mortalitäts Index, Berechnung de sInternat. Sterblichkeits Indexes für 14 Staaten, J. Körösi, Int. Statist. Bulletin 6, 1892, p. 305.

TABLE 38.

COUNTRIES.	Comparative Mortality Figures.		The Same reduced to a Standard of 100.
	(a)	(b)	(c)
Sweden,	1881	17.65	100
Norway,	1876	19.01	108
Denmark,	1880	20.50	116
Scotland,	1881	20.54	116
MASSACHUSETTS,	1885	**21.02**	**119**
Belgium,	1881	21.32	121
MASSACHUSETTS,	1890	**21.46**	**122**
Holland,	1880	22.89	130
France,	1882	22.92	130
Switzerland,	1881	23.03	131
Prussia,	1881	25.47	144
Würtemberg,	1881	27.01	153
Saxony,	1881	27.69	157
Italy,	1882	27.82	158
Austria,	1881	30.52	173

The figures in column *b* may be taken as the death rate which would have been recorded in each country in the year named in column *a*, had the population of such country been identical, so far as age distribution is concerned, with that of Sweden. By this means the mortality of each country is made comparable with that of Sweden and of the other countries named in the list.

Metropolitan Water Supply.

In the last annual report of the Board (page xlix) brief reference was made to the important duty which had been intrusted to the Board by the Legislature of 1893 of "considering and reporting upon the question of a water supply for the city of Boston and its suburbs within a radius of ten miles from the State House, and for such other cities and towns as in the opinion of the Board should be included in connection therewith."

The Board entered at once upon the work of investigation, and after making the necessary surveys submitted its report to the Legislature on the first Wednesday in February, 1895. This report forms a document of 270 pages, and includes the general report of the Board upon the proposed metropolitan water supply, the report of the consulting engineer, the report of the chief engineer, together with several additional reports and statements of experts upon the following special subjects: Growth of population in the Boston metropolitan district; Present and future consumption of water in the district, by Dexter Brackett, C. E.; Improvement of the quality of the Sudbury River water by drainage of swamps, by D. Fitz-Gerald, C. E.; The amount and character of organic matter in soils, by T. M. Drown, M. D.; Water supply of different qualities for different purposes, by Dexter Brackett, C. E.; Sanitary examination of Nashua River water-shed. It is fully illustrated with maps and plans showing the proposed water-sheds and sources investigated by the Board, methods of distribution, dams, and plans of drainage.

This general plan as reported by the State Board of Health was adopted by the Legislature of 1895 as the plan of water supply for the metropolitan district, and an act was passed providing for the appointment of a Metropolitan Water Board, to have the entire charge of carrying out the provisions of the act, with authority to expend $27,000,000 for this purpose. The estimated cost of the works proposed by the State Board of Health was $19,045,800. The additional amount authorized by the Legislature is mainly for the purpose of purchasing Boston's sources of water supply, aqueducts and pumping stations, and for the completion of a reservoir already begun by the city.

It has been thought advisable to reprint so much of this report as embraces the general report of the Board upon the subject in the present volume, and the same may be found on later pages.

Improvement of the Charles River.

By the provisions of chapter 475 of the Acts of 1893, the Board of Metropolitan Park Commissioners and the State Board of Health were constituted a "joint board, to investigate the sanitary condition, and to prepare plans for the improvement of the beds, shores and waters of the Charles River, between Charles River bridge and the Waltham line in Charles River, and for the removal of any nuisances therefrom."

The joint board was authorized to employ engineers and experts in making the proper surveys and devising plans for this improvement.

The report of this Board was made to the Legislature of 1894 in May of that year, the document relating to this subject being numbered as House Document, 775, 1894. It contains the reports of the joint board, the engineer and the landscape architects, together with several maps, plans and heliotype plates illustrating the proposed improvements, with several cuts illustrating similar improvements in other countries. The general report of this joint board is republished in the present volume on subsequent pages.

The Legislature of 1894, after considering the subject, enacted the following law, providing for the taking of land upon the banks of the Charles River. The question of constructing a dam and lock in the tidal basin of Charles River, with special reference to their interference with tide water and their effect on the harbor of Boston, was referred to the Harbor and Land Commissioners, who were directed to report upon the subject.

[Acts of 1894, Chapter 509.]

An Act to authorize the Metropolitan Park Commission to expend a Sum of Money in Addition to the Amounts heretofore authorized for Open Spaces along or near the Charles River.

Be it enacted, etc., as follows:

Section 1. The metropolitan park commission, for the purpose of acquiring and making available, under chapter four hundred and seven of the acts of the year eighteen hundred and ninety-three, open spaces for exercise and recreation along or near the Charles River, from the Essex street bridge, so called, at Cottage Farms, towards the source of the river, may expend the sum of three hundred thousand dollars in addition to any and all sums hitherto authorized to be expended by them by said act and

by all acts in addition thereto or in amendment thereof; and to meet the expenses incurred hereunder, the treasurer and receiver general shall issue a corresponding amount of scrip or certificates of indebtedness as an addition to the metropolitan parks loan, and establish a sinking fund to provide for the same; said scrip or certificates of indebtedness to be issued and said sinking fund to be established, assessed and collected in accordance with the provisions of sections nine, ten, eleven and twelve of chapter four hundred and ninety-three, as far as applicable hereto.

SECTION 2. Said act is hereby amended by striking out section eleven and inserting in place thereof the following: — *Section 11.* The metropolitan park commission shall annually estimate and certify to the auditor the expenses of preservation and necessary care of said public open spaces for the ensuing year, which expenses shall be apportioned by the treasurer and receiver general in the manner provided in the following section. [*Approved June 22, 1894.*

WATER SUPPLY AND SEWERAGE.

The act of 1886 entitled, "An act to protect the purity of inland waters," has proved one of the most useful laws in the history of State legislation.

Under the provisions of this act the Board was given a general oversight over the inland waters of the State, and was required to examine these waters with reference to their use as sources of domestic water supply. It was also required to recommend measures to prevent the pollution of such waters, and was authorized to conduct experiments to determine the best practicable methods of purification of drainage and sewage or disposal of the same. Quite as important was the requirement that the Board should give advice to cities and towns, corporations and individuals, relative to the introduction of water supplies and systems of sewerage and sewage disposal.

The amount and character of the work performed by the Board under this act may to some extent be understood by an examination of the reports of the Board from 1886 to the present year, including the special documents, vols. 1 and 2, published in 1890 and 1891. These reports of the Board have justly won a reputation which has entitled them to a place as standard works upon the subject of water supply and sewage disposal. In this department of the work of the Board have been planned some of the most important and extensive engineering undertakings within the limits of the State, such as the metropolitan sewerage system and the metropolitan water supply; the execution of both will involve the expenditure of $33,000,000.

The operations of the Board during the year 1894 under the provisions of this act may be found in the first part of the following report, page 1. The topics presented in this part of the report are the advice of the Board to cities and towns, the examination of water supplies, the examination of rivers, summary of water supply statistics and records of rainfall and flow of streams, the composition of the water of deep wells, the bacterial contents of ground waters and of deep wells, experiments upon the filtration of sewage and of water and physical and chemical properties of sands.

Food and Drug Inspection.

This department of the work of the Board has continued without interruption since the enactment of the food and drug acts in 1882.

Many of the difficulties attending the earlier inspections under this department and the enforcement of the statutes have been overcome; the amount of work done has gradually increased, while the cost of examination, per sample collected, has diminished.

The inconvenience of examinations in several different laboratories, and at a distance from the office of the Board, has been greatly diminished by concentrating nearly all of the analytical work at the laboratory in the State House, and under the supervision of a single chief analyst.

A full report of the work of the Board in this direction may be found under the head of Food and Drug Inspection.

Statistical Summaries.

The enactment of two new statutes, chapter 302 of the Acts of 1893 and chapter 218 of the Acts of 1894, has increased to a considerable extent the statistical work required of the Board. All this material has been grouped together in the present report, together with the voluntary returns embraced under the title of weekly mortality reports, the whole being entitled the Statistical Summaries. These comprise the following topics: —

1. Weekly mortality returns of cities and towns. (Voluntary.)
2. Summary of four infectious diseases with ratios of fatality (abstracted from the annual reports of municipal boards of health).
3. Summary of infectious disease notification (under provisions of chapter 302, Acts of 1893).
4. Summary of returns of deaths by boards of health in places having over 5,000 inhabitants in each (under provisions of chapter 218, Acts of 1894).

Antitoxine in Diphtheria.

Public hygiene is a life-saving department of work, and the operations of a board of health which pertain to the management and control of infectious diseases should constitute one of the most important functions not only of general but also of local health organizations. The saving of human lives, both individually and collectively, adds to the wealth and to the efficiency of the population, and such work deserves the highest praise and encouragement.

In the eighteenth century two of the most destructive diseases were small-pox and consumption. The great discovery of Jenner has reduced the mortality from the former and rendered it comparatively harmless, while the destructiveness of the latter has been diminished nearly one-half in the past fifty years, in consequence of better knowledge of the ways of living, better food, ventilation and the dissemination of popular information upon the subject.

Meanwhile, diphtheria has become, since its reappearance about the middle of the present century, an unusually destructive disease. Special attention has therefore been directed toward the means for diminishing the excessive mortality from this cause, and these efforts have been crowned with a promising measure of success.

At the recent Congress of Hygiene, held at Budapesth in Hungary, Dr. Roux announced the result of his researches and the success of the treatment which had been adopted by him at the Hospital des Infants Malades in Paris. During the years 1890, 1891, 1892 and 1893 the number treated for diphtheria at this hospital was 3,971, with an average mortality of 51.7 per cent. In the first six months of 1894 there were 448 admissions, with 109 deaths, — a mortality of 24.5 per cent. That this improvement was not due to the prevalence of a mild type of the disease was shown by the fact that in another hospital in Paris, where 520 children were received in the diphtheria ward during the same months, and were not treated with antitoxine, the mortality was 60 per cent. These results were compared by German investigators in the same direction, and this preventive mode of treatment may be considered as established, so far as the question of securing a decided reduction in the death rate from diphtheria is concerned.

With these facts in view, the State Board of Health entered upon the work of preparing antitoxine for distribution in the State during the fall of 1894, and for this purpose appointed Dr. J. L. Goodale

of Cambridge temporarily to supervise the work of preparation. Several horses were purchased, together with the necessary supply of smaller animals required for the purpose of testing and preparing the material produced. A laboratory was also established, for conducting the requisite processes.

It is too early to publish a digest or summary of the work accomplished in this direction. It is sufficient to say that the results thus far secured fully justify the continuance of the work thus begun, since a very considerable saving of life has undoubtedly been effected. A careful digest and summary will be prepared for publication in the next annual report, to embrace the results of the first year's work in this direction.

Improvement of the Concord and Sudbury Meadows.

During the legislative session of 1894 hearings were held in answer to petitions from inhabitants living upon the borders of the Concord and Sudbury rivers above the dam at Billerica, asking that legislation might be secured for the purpose of improving those rivers so that the level of the ground water in the meadows upon their borders might be lowered. As a result of these hearings an act was passed entitled "An act relative to the protection of the public health in the villages of the Concord and Sudbury rivers."

The first section of this act, requiring the services of the State Board of Health, is as follows: —

[Acts of 1894, Chapter 426.]

An Act relative to the Protection of the Public Health in the Valleys of the Concord and Sudbury Rivers.

Section 1. The state board of health is hereby authorized and directed to expend during the current year a sum not exceeding twenty thousand dollars, in dredging the bars in the Concord and Sudbury rivers above the dam at North Billerica and removing the weeds from said rivers, and in such other measures as shall, in the opinion of the board, tend to the restoration of the marshes along the said rivers to their original condition and to the abatement of malaria and other perils to the public health arising from the present state of the same. [*Approved May 24, 1894.*

At its first meeting, June 7, after the passage of the foregoing act, the Board voted to proceed at once with the necessary investigations preliminary to carrying out the work required by the act. It seemed necessary that a hearing should be granted to the residents included in the district specified, and a hearing was held by the Board

July 26, 1894, at which the inhabitants of the district were represented and the engineer of the Board outlined a plan of operations.

On August 2, the Board received a letter from the secretary of the committee of the landowners upon the borders of these rivers, signifying their approval of the work, and requesting the Board to carry out the plan outlined by the engineer of the Board.

The Board then advertised for proposals for dredging the rivers. Considerable delay was occasioned by the failure of the successful bidder to obtain the necessary bonds for the performance of the work. Advertisements were again made, and the contract was finally awarded to the Eastern Dredging Company.

Meanwhile, citizens of Concord living near the river requested that the channel of the river might be made wider through that region, offering also to pay for the extra expense of such widening. The Board will make a report upon this subject when the work is completed.

Health of Towns.

The last pages of the report are devoted to a digest of the principal facts of importance collected from the annual reports of local boards of health for the year 1894. The table of infectious diseases, notifications and deaths from the same causes has been transferred this year from this part of the report to that portion which is entitled "Statistical Summaries."

Routine Work of the Board.

The Board, in the performance of its duties under the provisions of the Public Statutes and of all succeeding acts relating to the Board, has held meetings at least once each month during the year, and such meetings of its standing committees as were essential to the proper performance of its duties. The operations of the Board are presented in detail in the present volumes, under the different topics relating to its prescribed duties.

Advice has been given very frequently at the office of the Board to local boards of health and to individuals requesting advice upon sanitary questions, and in instances where occasion required, visits have been made by the secretary, or by the engineers or other experts of the Board, to cities and towns, for the purpose of making investigations and inspection and giving advice.

Two public hearings were held by the Board during the year: one on June 14, in answer to a petition for the action of the Board rela-

tive to the Butchers' Rendering Association; and the other July 26, to the inhabitants of the district lying upon the borders of the Concord and Sudbury rivers.

The statistics of mortality compiled from the weekly postal card returns from the registering authorities of cities and towns have been published weekly during the year in the form of a bulletin, which also contains, once in each month, a report of the work done in the line of food and drug inspection, together with the prosecutions made under the food and drug acts. In addition to these items there is also published in the same bulletin a weekly report of the number of cases of infectious diseases reported by the local boards to the State Board of Health.

The following table presents certain statistical data relative to the routine work of the Board: —

STATISTICAL TABLE FOR THE YEAR ENDING SEPT. 30, 1894.

Whole number of samples of foods and drugs examined during the year,		6,824
Samples of milk examined (included in the foregoing),		3,501
Whole number examined since beginning of work in 1883,		60,397
Whole number of samples of milk examined since beginning of work in 1883,		30,577
Number of prosecutions against offenders during the year,		90
Number of convictions during the year,		77
Amount of fines secured during the year,		$2,625 00
Force employed in general work of Board at central office, State House: —		
Secretary,		1
Clerks,		2
Messenger,		1
Total,		4
Force employed at central office, State House, Boston, for food and drug inspection, chemists and assistants,	2	
At Amherst,	1	
		3
Inspectors,		3
Total,		6

STATISTICAL TABLE FOR THE YEAR 1894.

Applications for advice from cities, towns and others: —	
Relating to water supply,	40
Relating to sewerage and drainage,	10
Relating to pollution of streams,	3
Total,	53

Number of samples of water examined chemically and microscopically at the Massachusetts Institute of Technology,	2,006
Number of samples of sewage and water examined chemically and bacterially at the Lawrence Experiment Station,	2,534
Number of samples of sand examined chemically and bacterially at the Lawrence Experiment Station,	420
Number of samples of sand examined mechanically at the Lawrence Experiment Station,	234
Additional samples examined bacterially at the Lawrence Experiment Station,	6,295
Total number of samples examined,	11,489

Force employed at central office: —*		
Chief engineer,	1	
Assistant engineers,	2	
Stenographer and clerk,	1	
	—	4
At Massachusetts Institute of Technology: —		
Chief chemist,†	1	
Assistant chemists,	5	
Chief biologist,†	1	
Assistant biologist,	1	
	—	8
At Lawrence Experiment Station: —		
Chemists,	2	
Bacteriologists,	3	
Other assistants and laborers,	4	
	—	9
Total ordinary force,		21

The numer of applications for advice under the provisions of chapter 275, Acts of 1888, received since July, 1886, when the act relating to water supply and sewerage first went into operation, is as follows: —

1886,	8	1892,	56
1887,	22	1893,	51
1888,	28	1894,	53
1889,	38		
1890,	23	Total,	332
1891,	53		

* Not including the force employed upon the metropolitan water supply investigations.

† The chief chemist and biologist, although located at the Massachusetts Institute of Technology, have the oversight of the chemical and biological work at the Lawrence Experiment Station.

Recommendations.

The following recommendation was made to the Legislature at the beginning of the session of 1895.

The Board recommends the continuance of its investigations now being carried on as authorized by the provisions of chapter 375 of the Acts of 1888. For this purpose, and to make the necessary investigations in order to advise cities, towns, corporations and individuals in regard to the best methods of assuring the purity of intended or existing water supplies and the best method of disposing of sewage, and to carry out the other provisions of chapter 375 of the Acts of 1888, the Board estimates that the sum of $30,000 will be required.

Expenditures.

The work of the Board is conducted under the provisions of several statutes, and for its different departments of work these appropriations are annually made, one for the general work of the Board, one for the inspection of food and drugs and a third for the carrying out the provisions of chapter 375 of the Acts of 1888, relating to the protection of the purity of inland waters. In addition to the foregoing, special appropriations have been made from time to time, as occasion has demanded, for the purpose of enabling the Board to conduct special lines of investigations.

The appropriations for the different departments of work in 1894 were as follows: —

For the general work of the Board, ...	$10,800
For food and drug inspection, ...	11,500
For carrying out the provisions of chapter 375, Acts of 1888, .	27,000

In addition to the foregoing regular lines of work the Board continued its investigations upon the subject of a general water supply for the metropolitan district, and was also authorized to expend $20,000 for carrying out the provisions of an act "relative to the protection of the public health in the valleys of the Concord and Sudbury rivers" (see page cviii).

The expenditures in 1894 under the foregoing appropriations were as follows:—

For the General Work of Board, Sept. 30, 1893, to Sept. 30, 1894.

Salaries,	$4,982 98
Printing,	1,932 68
Travelling expenses,	474 62
Special investigations,	589 54
Postage,	243 54
Books, subscriptions and binding,	310 66
Express,	282 37
Stationery,	290 74
Telephone,	200 05
Type-writer,	95 00
Type-writer and library supplies,	78 01
Office incidentals,	154 02
Messenger services,	322 57
Telegrams,	9 18
Drafting woodcuts,	55 50
Total,	$10,021 46

For Food and Drug Inspection, for Year ending Sept. 30, 1894.

Salaries of analysts,	$4,500 00
Salaries of inspectors,	3,900 00
Travelling expenses and purchase of supplies,	1,660 00
Apparatus and chemicals,	205 40
Furniture and fittings at laboratory,	1 95
Legal services,	5 00
Gas,	20 00
Extra services,	48 00
Milk cans, tags, washing windows and sundry small supplies,	24 29
Total,	$10,364 64

Expenses under Chapter 375, of Acts of 1888 (Protection of Purity of Inland Waters), for Calendar Year 1894.

Salaries, including wages of laborers at Lawrence Experiment Station,	$23,153 54
Apparatus and materials,	1,332 24
Rent of rooms at Massachusetts Institute of Technology,	750 00
Rent of Lawrence Experiment Station (thirteen months),	162 50
Travelling expenses,	417 62
Express charges,	558 72
Use of tools and office, Lawrence Experiment Station,	360 07
Books, stationery and drawing materials,	154 20
Maps, blue prints and photographs,	21 44
Paid for collecting samples of water,	7 13
Postage stamps,	51 85
Messengers and telegrams,	8 44
Printing,	22 25
Total,	$27,000 00

Total Expenditures, Investigation of Metropolitan Water Supply (Acts of 1893, Chapter 459).

Salaries of engineers, experts and assistants,	$32,168 53
Travelling expenses and subsistence of engineers,	3,240 01
Laborers employed in making borings,	3,545 05
Boring apparatus, repairs and materials,	1,821 94
Digging test pits,	254 30
Printing,	50 32
Stationery and drawing materials,	371 24
Instruments and repairs,	149 73
Books, maps and map mounting,	201 44
Office fixtures and furniture,	43 55
Small supplies and miscellaneous expenses,	227 28
Legal services,	426 61
Total,	$42,500 00*

Improvement of Sudbury Meadows.

Salaries of engineers and assistants,	$774 88
Travelling expenses and subsistence of engineers,	113 04
Boat hire,	15 50
Drawing material, stationery, etc.,	4 68
Labor,	137 42
Lumber,	7 84
Photographs, blue prints, etc.,	4 85
Sundry incidentals,	13 67
Surveying instruments and repairs,	4 70
Total,	$1,076 58

H. P. WALCOTT,
H. F. MILLS,
F. W. DRAPER,
G. C. TOBEY,
J. W. HULL,
C. H. PORTER,
State Board of Health.

* This sum includes the whole amount expended in the two years 1893 and 1894.

REPORT

OF THE

STATE BOARD OF HEALTH

UPON A

METROPOLITAN WATER SUPPLY.

REPORT OF THE STATE BOARD OF HEALTH

UPON A

METROPOLITAN WATER SUPPLY.

To the Honorable the Senate and House of Representatives of the Commonwealth in General Court assembled.

The State Board of Health, acting under the authority of chapter 459 of the Acts of 1893, has investigated and considered the question of a water supply for the city of Boston and its suburbs within a radius of ten miles from the State House, and for such other cities and towns as, in its opinion, should be added thereto; and has also made the additional investigations set forth in the second section of the same act, and now desires to submit the following report: —

The act under which the Board has conducted this inquiry apparently provides for the same general treatment of the question of water supply as was adopted by the General Court of 1887 for the creation of a sewerage system for a somewhat smaller district. Substantially all the arguments that were urged by this Board for the metropolitan sewerage system, which, built in accordance with our recommendations, is now nearly completed, may be used with even greater force in aid of any well-devised plan for giving to a still larger district a sufficient supply of the best water attainable.

F. P. Stearns, C.E., chief engineer of the Board, has prepared the very full and accurate statement of the present and future resources of water available for this metropolitan district, together with all necessary details as to the structures at the great reservoir, the aqueduct leading from it, the new pipe lines and pumping stations, within the district; and, in addition to the information already in possession of the Board, has been able to state the results of many new inquiries undertaken for the purposes of this report. The financial

aspects of the problem are also treated by him in an instructive manner.

J. P. Davis, C.E., who has been for a series of years entirely familiar with all the great municipal works for water and sewerage of the metropolitan district, has made a careful examination of the work of our engineer, and finds it to be well considered and trustworthy. Mr. Davis was for many years city engineer of Boston, and in this capacity designed and had charge of the construction of the works for taking water from the Sudbury River. He has also been consulting engineer to the Aqueduct Commission of the city of New York, and was one of the experts consulted as to the proposed Quaker Bridge Dam.

Dexter Brackett, C.E., has embodied in two appendices the results of observations and studies to which he has devoted many years.

Another appendix, numbered 3, contains a description by Desmond FitzGerald, C.E., of plans for the draining of swamps, which are now under consideration for the improvement of the Sudbury water-shed.

Dr. Drown's paper upon the influence exercised by organic matter in the soil of reservoirs upon the water stored therein has so much that bears upon the recommendations of this report that we again publish it in Appendix 4.

All the special information that may be found necessary to explain or support the compressed conclusions of our own report will be supplied by the valuable reports of the eminent authorities above enumerated.

The most familiar experience of this part of the world, at least in the matter of its water supplies, has been the failure of sources originally supposed to be abundant to properly meet the wants of their respective communities for any considerable length of time. The plans of the city of Boston, beginning with its first scheme for a general water supply in the year 1825, have proved no exception to this rule, and yet this city has had the services of the ablest men of their day.

The reason for this constant disappointment is easily discovered. The quantity of water which the householder of to-day demands for the conveniences as well as for the necessities of his daily life has increased beyond all expectation. If this enlarged quantity can be secured without undue delay and without such injury as may easily

be made whole, it is evidently for the general welfare that such provision should be made; for it seems to us reasonable to claim that no small share in the improved and still improving state of the public health may be traced to the measures now adopted for the protection of the purity of waters and to the greater cleanliness of person, clothing and all surroundings which inevitably result from a practically unlimited freedom in the use of water. It is essential, then, to determine, if possible, the amount of water needed at the present day, with such forecast as to future requirements as can be safely made.

It is, of course, true that a comparatively small amount of pure water would meet all the demands for drinking and cooking, and that a water of inferior quality would answer for other domestic purposes as well as for all municipal requirements and the demands of manufactures; but no satisfactory arrangement has as yet been made by which two kinds of water can be economically and safely distributed through the streets and buildings of cities and towns.

It was discovered by this Board, some years since, that no inconsiderable portion of the cases of typhoid fever found in certain manufacturing towns in this State was the result of the careless drinking of a dangerous water, which is used in the mills for mechanical purposes only, is understood to be dangerous and is distinctly so marked; but this inferior water was still used by the operatives, because it was sometimes cooler, was tasteless, and generally more accessible.

The Board has hoped that it might be possible to devise some plan by which the very limited amount of quite pure water really needed in our houses might be secured and distributed; but no satisfactory method has as yet suggested itself, nor with the present outlook for an abundant supply of very good water does such a plan seem to be an urgent need either on grounds of health or economy.

The average daily consumption of water in the metropolitan district for the year 1894 was 79,046,000 gallons, the average daily capacity of the sources now in existence for the supply of this district was only 83,700,000 gallons; that is to say, the average daily supply is only 4,654,000 gallons in excess of the actual needs. Though some of the sources of supply to the district are capable of yielding larger quantities of water than are at present furnished (as will be shown in detail in the accompanying report of our engineer), we are satisfied that even a very thorough development of all these

sources will barely carry the district safely through a year of unusual drought, should such a season occur before the date at which the works, hereafter to be described, can be put in condition to increase the supply; and this would be true even though the cities or towns which might find themselves possessed of a surplus supply could transfer it to their neighbor in want.

The population of this metropolitan district was, by the United States census of 1890, 844,814. Estimates which have been carefully made, and with a due regard to the diminution in rate of increase by reason of the depression in business, place the population for the year 1895 at 984,301. The water works of the city of Boston now supply nearly 75 per cent. of all the water used in the metropolitan district. The daily average consumption of those cities and towns receiving water from the Boston works was 99 gallons in 1893, and the average for the entire district now under consideration was, for the same year, 83 gallons. It seems to be generally true that the nearer we approach the centres of population the greater becomes the use of water; and, with the inevitable growth of Boston and its suburbs, it does not appear to us wise to calculate upon a requirement per inhabitant of less than 100 gallons for the long period of years for which we seek a supply.

We have not deemed it necessary or advisable to busy ourselves with the insoluble problem of the probable future increase of population in and about Boston. We have assumed that the growth will go on as it has gone on during the last quarter of a century; and for a population determined by such principles we have made provision.

While every effort has been made to reconcile the views of the local authorities with our own as to their respective requirements both in regard to quantity and quality of water needed and their capacity to meet such demands, the Board has in several cases arrived at results quite different from those held by these authorities. It is assumed that no portion of this large and intimately associated community will accept for any length of time a water inferior to that enjoyed by their neighbors, either in healthful qualities or attractive appearance and odor; and it will not be profitable as a municipal investment to offer the stranger seeking a new home anything so essential to his health and comfort as water is, that shall be decidedly poorer than the article distributed on the other side of the town's borders.

It has, therefore, been assumed by us that the various communities under consideration will take, sooner or later, the better water, pro-

vided that the cost of taking it is not in excess or greatly in excess of that of an existing and inferior supply.

It will also be found to be true, we think, that a very large amount of the best water can be provided for the district at a price per head far below that at which any municipality within the district, with the exception probably of Brookline, Newton and Waltham, can supply a water of anything like an equal quality. Moreover, in our opinion, the most favored locality in this region has no prospect of obtaining beyond the next twenty or twenty-five years any source of supply that can be favorably compared, either on grounds of health or economy, with the source to be later described. It is by no means certain that Waltham, even with its present abundant and good supply, can continue to depend through a series of years upon water filtered uninterruptedly in ever-increasing quantities from a river more or less polluted.

Of the communities composing the metropolitan district, those using 80 per cent. of the full amount of water will need the metropolitan supply nearly as soon as it can be furnished. It is probably possible for those using 10 per cent. of the full amount to extend their works so that they may give them a supply for twenty or twenty-five years, and the remaining 10 per cent. will need the metropolitan supply within a shorter time.

The works of distribution have been so designed that the first cost will be increased as little as practicable, and that they may be in condition to supply these communities when they shall need the water, by additions to the works first constructed; but some expense must necessarily be incurred at first, on account of the prospective use by these communities.

For the purpose of determining which cities and towns should be included in the district to be formed, a careful review has been undertaken of all the facts within our reach which have a bearing upon this question, — facts which will be found duly stated in the subjoined report of the engineer, Mr. Stearns; and we accordingly recommend that the cities of Boston, Cambridge, Chelsea, Everett, Lynn, Malden, Medford, Newton, Quincy, Somerville, Waltham and Woburn, and the towns of Arlington, Belmont, Brookline, Hyde Park, Lexington, Melrose, Milton, Nahant, Revere, Saugus, Stoneham, Swampscott, Wakefield, Watertown, Winchester and Winthrop, twenty-eight cities and towns, containing, in 1890, 848,012 inhabitants, constitute the metropolitan water district.

Inasmuch as the cities of Cambridge, Lynn, Newton, Waltham and Woburn, and the towns of Brookline, Lexington, Nahant, Saugus, Swampscott and Winchester, together containing, in 1890, 210,252 inhabitants, believe that they have a sufficient supply for some years to come, we do not recommend that they be provided with water from the metropolitan supply until they formally express their wish for it. These municipalities contained about one-fourth of all the people living in the proposed district in the year 1890. We have no hesitation in recording our own belief that the period at which this supply will be demanded by them is much nearer than they now anticipate; but their participation in the scheme is not essential to the success of the undertaking, nor will their absence render the immediate procuring of a new water supply any the less necessary.

After a thorough revision of all the sources of water which have been suggested or which we could discover, we selected three which seemed worthy of critical examination, — Lake Winnipiseogee in New Hampshire, the Merrimack River above Lowell and the Nashua River above Clinton.

Lake Winnipiseogee has for many years been held to be the ideal of all that was needed in the way of a perfect source of pure water, and it is capable of furnishing an abundant and excellent supply. The clear depths of its waters and the apparent freedom from pollution along its shores, unlike many of the artificial reservoirs hitherto constructed, have created so strong a popular belief in its necessary superiority to anything artificial that it may not be out of place to direct attention for a moment to some of the defects to be found even here. The permanent population on the territory draining to the lake is not large, — 35 persons per square mile; but the attractive shores have become the favorite summer camping-ground of thousands, and the amount of the most serious forms of pollution directly entering the water of the lake must be large and ever-growing. Even though the State of New Hampshire might allow a certain amount of water to be taken from this lake for domestic water supply within her own limits, it is not probable that she would consent to the withdrawal of amounts of water so large as to injure her own manufacturing industries, or to give to the people of another State any authority to interfere by police regulations with the unhampered enjoyment by her own citizens of her beautiful pleasure-grounds.

The expense, however, of constructing a conduit over the shortest and best route which it has been possible to discover, and for distributing this water through the district, amounts to $34,000,000. This large sum does not include the cost of the damages inflicted by the diversion of water and charges incident thereto; and we are confident that the water thus obtained would have no greater value than supplies which can be obtained at much smaller cost within the limits of this State and protected by our own laws.

Examinations have also been made with the view of taking the water of the Merrimack River above Lowell, subjecting it to efficient filtration and bringing it down into the metropolitan district. The quantity of water that could be obtained in this way and for this purpose is unlimited; and, if there were no way of obtaining a better supply of water and one which was above suspicion, it would be practicable to introduce water from that source at a cost somewhat less than from any other source considered.

The estimated cost of filtering and conveying this water to the metropolitan district is $17,500,000; but in the opinion of the Board it will be better to pay 10 per cent. more for a supply from a source that has not been polluted. The experiments carried on by this Board for a succession of years at an experiment station in Lawrence under the immediate direction of H. F. Mills, C.E., a member of this Board, and the filter constructed in connection with the water works of that city, have shown that waters as polluted as those of the Merrimack can be effectually filtered and rendered safe for domestic use; but it is also true that filtering areas require continuous care on the part of well-trained attendants, and that, in a few instances at least, inefficient administration or inherent defects of construction have allowed disease germs to pass through filters which were assumed, by good authority, to be a sufficient protection.

We are the more easily led to reject the filtered waters of the polluted Merrimack because we have found an entirely satisfactory water in the South Branch of the Nashua River above the town of Clinton. We find that the conduit of the Boston water works was built of much larger capacity than was needed for the conveyance of the amount of water to be derived from the Sudbury River, being capable of taking 50,000,000 gallons a day more than is at present supplied to it. The territory from which an additional supply for this district may be sought is thus moved out to the westerly end

of this conduit, or to the westerly end of the valley and reservoir connected with this conduit.

The first source of considerable size found to the west of this point is the above-named South Branch of the Nashua, which, at the town of Clinton, has a water-shed of 118.23 square miles, consisting of a sparsely settled district containing but 69 persons to the square mile. The southerly and easterly slopes of Wachusett Mountain which bound this territory to the north and west are not well adapted to agriculture, and offer few inducements to the establishment of manufactures. In this section the rate of increase of population has been very slight, and the distance from centres of population is such that no more rapid rate of growth can be expected in the future.

In this river, a short distance above the Lancaster Mills in Clinton, a dam can be built which will raise the water 107 feet above the surface of the existing mill-pond, and flowing to the average depth of 46 feet an area of 6½ square miles, with its high-water mark 385 feet above the level of high tide in Boston harbor. This reservoir will have a capacity of 63,000,000,000 gallons, and the territory draining into it will supply, in a series of very dry years, 111,000,000 gallons of water daily, which, with the 62,000,000 gallons obtainable from the Sudbury and Cochituate water-sheds, will make the total capacity of the combined sources 173,000,000 gallons, which is double the capacity of all the sources now utilized by the metropolitan district.

The reservoir can be connected with the new Reservoir No. 5 now constructing by the city of Boston in the Sudbury River system. The connection would be made by an aqueduct a little less than 9 miles long, and an open channel about 3 miles long following the course of an existing brook. This aqueduct is designed to be built low enough to take water from the level of the present mill-pond in Clinton; so that, should it become necessary to increase the supply to the metropolitan district before the dam and reservoir are completed, the ordinary flow of the river could be brought down into the Sudbury system as soon as the aqueduct is built.

The very great merit of the plan now submitted is to be found in the fact that this extension of the chain of the metropolitan water supplies to the valley of the Nashua will settle forever the future water policy of the district, for a comparatively inexpensive conduit can be constructed through to the valley of the Ware River, and

beyond the Ware River lies the valley of the Swift; and, in a future so far distant that we do not venture to give a date to it, are portions of the Westfield and Deerfield rivers, capable, when united, of furnishing a supply of the best water for a municipality larger than any now found in the world.

The expense of this great scheme is comparatively moderate, because the water-sheds in question are sparsely settled, lie among the higher regions of the State, and are not likely to become the seat of manufacturing industries. Moreover, all these streams can be brought down by their own natural flow from appropriate reservoirs to the existing distributing basins in the metropolitan district.

The water in the South Branch of the Nashua River is at present of good quality, and, with the small population upon its drainage area, it will not be difficult to protect it from impurities in the future; but, in the opinion of the Board, the large reservoir to be constructed will serve as a means of very much improving the quality of the water; its area and depth are so great that it will contain, at nearly all stages at which it is proposed to hold the water, a full year's supply when double the quantity now used in the metropolitan district is drawn from it and the Sudbury and Cochituate areas. During the long period through which water remains in this reservoir a bleaching and purifying process will go on, which will probably cause the death of all the disease germs which may be turned into it from contributing streams, and the water thus become more agreeable to the sight and taste, and be, in fact, more wholesome than the present water from any of its contributing streams. In order that this may be the case, the Board has thought best to increase the depth of the reservoir by raising the dam, and to remove from its area the vegetable matter and soil which may cover it, and thus expend about $4,000,000 in rendering the water of the best quality practicable.

So many advantages are offered by larger storage reservoirs, as compared with the smaller basins, which local geographical peculiarities have compelled the metropolitan district to build hitherto, that it has seemed advisable to us to urge the completest possible preparation of this new reservoir.

After this new water has been brought into the Sudbury system, it will pass down into Chestnut Hill Reservoir, where it will for the first time require to be pumped to an elevation of 30 feet, sufficient to give an additional head to the Boston low-service system and to

carry over to Spot Pond the supply needed for the northerly portion of the metropolitan district. In our estimates of cost a sum of money has been set aside for the improvement of Spot Pond, principally for removing its shallow flowage, and we believe it will then be a valuable distributing reservoir and restored to its normal height.

It is estimated that no other conduit will be required in addition to the present one from Sudbury River to Chestnut Hill Reservoir for ten or more years; but before the end of this period it will be necessary to build an additional conduit, extending from Reservoir No. 5 of the Boston water works to a point in the town of Weston not far from the Charles River, at such a height that the water may be conveyed in pipes to Spot Pond, and be distributed through the low-service system in the metropolitan district by gravity. This aqueduct will be 13½ miles long, and is designed to convey 250,000,000 gallons of water per day.

Spot Pond is selected for a general distributing reservoir in order that the low-service district may have a pressure 30 or 40 feet greater than would be supplied by Chestnut Hill Reservoir; this increased pressure is rendered necessary in order to include large areas in the district which would be inadequately served by the lower reservoir and by the custom of constructing very high buildings upon the low-lying territory.

The method of distributing the water over the metropolitan district is given in detail in the report of the chief engineer; it is designed to supply to each community within the district a sufficient quantity of water for its use at a pressure sufficient for all requirements within its territory, and it will be feasible to supply all the highest portions of the district more efficiently than at present from a much smaller number of stations and at a much diminished charge for annual maintenance.

In considering the plans for the proposed reservoir above the Lancaster Mills, we have been impressed by the very serious changes which will be produced in the towns of Boylston and West Boylston. It does not appear to us to be a very important objection to our plan that certain mill sites will be 80 feet beneath the surface of the basin, nor that the homes of many industrious people dependent upon these mills for their living will be also submerged, because all these can be paid for, and an equivalent will be given, — damages for which we have caused careful estimates to be made. But we have not deemed it to be within our province to decide upon a plan for making good

the many other losses that must of necessity fall upon these sorely diminished townships, — the burden of a town debt for which much of the available security has been taken away, the loss of a near market for the farmer upon the outskirts of the town, and the many other losses which will naturally suggest themselves. We can only state that we recognize the existence of these losses, that we believe some form of compensation should be granted, and that the benefit to the metropolitan district by reason of a pure water supply in abundant quantity will be so great that this district, which contains more than half the taxable property of the State, can afford to pay for all the injury inflicted; at the same time we must leave the suggestion, even, of the nature of the remedy, to the wisdom of your honorable body.

The total assessed valuation of West Boylston for 1894 was . .	$951,610
Assessed value of property to be taken, ...	557,730
The total assessed valuation of Boylston for 1894 was	429,435
Assessed value of property to be taken, ...	165,200

In preparing the estimates for the cost of the great work here sketched out, we have brought to our assistance the best expert aid, and believe that the works can be constructed within the estimates which have been liberally made with the usual allowance for contingencies.

It may also be of interest to you to know that, of the whole water-shed of the Nashua River above the city of Nashua in New Hampshire, at which place the Nashua enters the Merrimack, the proposed reservoir cuts off 22 per cent.; but, with the provision which is inserted in the draft of an act herewith submitted for allowing a stated quantity of water to be discharged into the mill-pond below the reservoir dam, the deprivation of water will not be so extensive as the proportion of reservoir water-shed to the whole water-shed of the Nashua would indicate.

The estimates of cost have been made by Mr. Stearns, the chief engineer of the Board. They have been made from carefully prepared designs, and are intended to be sufficient to include the full cost of the completed work.

The cost of the works necessary to supply all the communities of the metropolitan district for the next ten years with the main part of the works of sufficient capacity for a long future is estimated as follows: —

Reservoir on Nashua River, including the cost of land, buildings and water rights taken, the relocation of roads and railroads, the removal of all soil from the site of the reservoir, the construction of dams and dikes and all incidental expenses, ...	$9,105,000
Improvement of the water-shed of the Nashua River and of the Stony Brook branch of the Sudbury River by the diversion and purification of sewage and drainage of swamps, ...	513,000
Aqueduct from the Nashua River to the Sudbury water-shed and open channel from the end of the aqueduct to Reservoir No. 5, . .	2,265,000
Additional forty-eight-inch pipe from Dam No. 3 to Dam No. 1 and across the Rosemary valley, ...	78,800
Pumping stations reservoirs and pipe systems for elevating and distributing water to all of the cities and towns in the metropolitan district, including the improvement of Spot Pond, . . .	5,584,000
Damages for the diversion of water from the Nashua River and incidental damages not included above, ...	1,500,000
Total first cost of proposed works for supplying water to *all* of the cities and towns in the metropolitan district, . . .	$19,045,800

The estimates of damages for the diversion of water from the Nashua River are believed by the Board to be ample to cover all reasonable demands, and are made large enough so that it is probable that some of the more important can be settled within the estimate without litigation.

It is not proposed in the driest year to lower the water in the reservoir more than sixty feet, and there will always be a great fall between the surface of the water in the reservoir and in the aqueduct leading from it. It is estimated that this fall may be utilized to furnish 1,000 horse-power by day and 500 horse-power by night for the first fifteen years, and nearly as much for the following years.

The estimated first cost of the proposed works for supplying water to all of the cities and towns in the metropolitan district is, as above stated, ...	$19,045,800
Within the next ten years, if the water is used by all of the cities and towns, there will be required an additional expenditure for an aqueduct from Reservoir No. 5 to Weston, and for main pipes and an aqueduct therefrom to the existing distributing system and to Spot Pond of	4,982,000
In the second ten years a further expenditure will be necessary for additional pipes from Weston and for improving a portion of the Sudbury River water-shed, not included in the first estimate, of .	1,300,000
Total expenditure for full development of Nashua River source, and for a supply of 173,000,000 gallons of water per day distributed to all of the cities and towns in the metropolitan district, ...	$25,327,800

After these twenty years, should the growth of the district be as estimated, additions will have to be made by adding certain tributaries of the Assabet River, or by extending the works to the valley of the Ware River, either of which can be done at a comparatively small cost.

The annual cost for interest, sinking fund and maintenance of the works for supplying the whole district when the works are first completed is estimated to be ninety-three cents per inhabitant, and the cost will decrease with the growth of population.

In conclusion, we desire to again call your attention to our profound conviction of the need of prompt action in entering upon works of construction which cannot for years be completed, and of which the absolute necessity will at an early day be forced upon this community; and we are confident that we have pointed out an economical as well as practicable means of securing one of the most essential conditions for healthy human life.

H. P. WALCOTT,
J. W. HASTINGS,
H. F. MILLS,
F. W. DRAPER,
G. C. TOBEY,
J. W. HULL,
C. H. PORTER,
State Board of Health.

REPORT OF THE JOINT BOARD

UPON THE

IMPROVEMENT OF CHARLES RIVER.

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IMPROVEMENT OF CHARLES RIVER.

To the Honorable the Senate and House of Representatives of the Commonwealth in General Court assembled.

The undersigned, members of the joint board, consisting of the Board of Metropolitan Park Commissioners and the State Board of Health, to whom was referred, by chapter 475 of the Acts of 1893, the investigation of the sanitary condition, and the preparation of plans for the improvement of the beds, shores and waters of the Charles River, between Charles River bridge and the Waltham line on Charles River, and for the removal of any nuisance therefrom, respectfully submit the following report: —

The two boards named in the act met for organization August 10, 1893. H. P. Walcott was elected chairman of the joint board and H. S. Carruth, secretary. At a later date F. P. Stearns, C.E., was appointed engineer to the board, and Messrs. Olmsted, Olmsted and Eliot were asked to consider the subject of the improvement of the river, to submit a report thereon and to prepare a plan of the improvements recommended. Mr. Eliot had been a member of the Charles River Improvement Commission appointed under authority of chapter 390 of the Acts of 1891, had acquired complete familiarity with the actual condition of the river, and had made, in a public document, valuable suggestions for its improvement. Dr. Robert W. Greenleaf of Boston was asked to make a sanitary survey of the district designated in the act.

The members of the board have personally examined the river and its banks at many times and under various conditions. They have carefully considered the reports made to them by the experts employed, and have reached the following conclusions.

The position of the Charles River, in its relation to the metropolitan district, has necessarily a very great influence upon the health and comfort of the people living in its vicinity. So long as the stream was comparatively unpolluted its banks were occupied at eligible sites by dwellings of the better sort. The increase of pollution and the consequent nuisance occasioned by it have driven from the banks those who could afford to establish new homes in more attractive regions, and the places of these have been taken by a population less sensitive because they cannot afford to avoid offensive surroundings, or by manufactories that seek the stream for commercial advantage or to be at a distance from neighbors likely to complain of offensive processes incident to the business carried on. Even in those portions of the river where the vast quantities of salt water brought in by the tide so far diminish the degree of pollution that offensive odors are not observed except at low tide and in consequence of local causes, and where some of the finest residences of the Back Bay district of the city of Boston are to be found, — even here the river has ceased to be a welcome neighbor except so far as the views to the distant hills to the north and west are enhanced by the water in the not too near foreground, a foreground consisting of a poorly kept alleyway behind a line of unsightly sheds and stables situated at the rear of the lots on the north side of Beacon Street, a rude stone wall, upon which grow tufts of seaweed and unsightly grasses, holding as sponges do the floating putrescible materials that come in contact with them, and at the base of the wall, at low tide, a muddy expanse of many acres, marred by rubbish of every description.

So many of the great cities of the world have made use of the banks of rivers and basins as sites for their finest public and private buildings and ornamental grounds that we cannot escape from the conviction that the disinclination to so use the Charles River within the limits under consideration rests either upon nuisances already in existence or the apprehension of danger to health. The river runs through the very centre of the metropolis and upon its shores should naturally be placed its most attractive structures, its monuments and its finest dwellings. It does not seem appropriate that this territory, so favored by position, lying at the very heart of our great city and upon the borders of a stream not necessarily offensive, should be condemned to its present ignoble and noxious uses. If any streams or any low lands are to be so used in the vicinity of Boston

it would be well that they should be as far as possible from the centre. An enumeration of the people who are actually resident upon the territory which lies within a distance of two miles upon either bank of the river, throughout the district now under consideration, shows a population of not less than 500,000. Here in the future will probably be found, as now, the bulk of the metropolitan population.

The banks of the river and the exposed flats have become from year to year more offensive until, on certain portions of the river, the people living near the stream have been exposed to the disagreeable and probably injurious emanations therefrom. So far reaching had this nuisance become that during the summer of 1892 a very large portion of the territory of Old Cambridge was subject to its influence, and a petition was addressed to the State Board of Health signed by hundreds of householders, and by nearly all the practising physicians of that portion of the city, praying that some relief might be given from a condition of things believed to be positively injurious to health, and known to be so offensive that windows had to be closed during the period of low tide in the river.

The medical profession believes that the gases arising from decomposing organic materials are injurious to health; it has not been proved, however, that these gases do produce some one distinct disease, but rather that the continued breathing of them lowers the vital resistance and predisposes the person exposed to them to diseases of various kinds and all degrees of severity. But even if the physicians are in error in believing such emanations to be a danger to health, it is quite certain that the owners of lands or houses on the borders of such foul smelling streams suffer a pecuniary loss in the diminished value of their property, a loss from which they should be protected if it be practicable to do so.

In recent years it has been thought that the steady progress of malaria in the valley of the Charles has had a very close connection with the increasing pollution of the stream; the careful examination into this subject by Dr. Greenleaf does not show, however, that the cases of malarial fever have been in such near connection with the river as to make it probable that the contaminations of its waters have had any direct influence upon the spread of the disease. Dr. Greenleaf, in the course of a house-to-house survey of the district adjoining the river, did, indeed, discover cases of malarial fever, but a satisfactory explanation of their occurrence was almost invariably found,

either in local conditions not dependent upon the state of the river, or else by exposure of the affected individuals in localities known to have become malarial in recent years. His observations lead to the same conclusions in this inquiry that other competent authorities have drawn in all parts of the world, that the most important condition to be sought for defence against the malarial infection is a thorough drainage of the soil, together with a maintenance of the water contained therein at an unchanged level.

Two plans occur to us for the relief of the conditions thus briefly sketched, assuming in both cases that the Metropolitan Sewerage System, now nearly completed, will remove the more serious forms of pollution : —

First. To dredge all flats now exposed, and to continue the embankment constructed in the substantial and attractive form used by the city of Boston at the Charlesbank, ultimately carrying this construction through the whole length of the estuary and upon both banks.

Second. To maintain the water in the river through a greater or less length in its course at a permanent high level by the construction of a dam.

The objections to the first plan are these : While the river would rise and fall against a vertical wall, thus exposing the smallest possible surface at the banks, even this surface would soon become defaced by growths more or less offensive, as has already happened to the recently constructed walls in the Charles River basin. The embankment would be many miles in length, would entail very extensive fillings of low lands in order to render such lands available for any public use or profitable private occupation, and the general effect would not be pleasing to the eye, except when the water is at or near high tide, and lastly, the difficulties of the construction of walls on account of poor foundation and their great expense would preclude for the present at least the building of them.

Having a due regard to the imperative need of some measure of relief in this valley, it does not seem safe to longer delay the adoption of a sufficient remedy, and we therefore recommend the second plan, the erection of a dam high enough to keep even extreme tides out of the basin and the maintenance of the water at a permanent level, in accordance with the plan of our engineer, F. P. Stearns, C.E., herewith presented.

The place selected for the dam is about 600 feet above Craigie's

bridge, where the river is not more than 1,100 feet wide. The details of this structure have been so thoroughly considered that we confidently believe that it will answer the purposes for which it is designed, the maintenance of a nearly permanent level at all times, and no greater interference with commerce than would be produced by the operation of a drawbridge, — indeed, not so much, should the drawbridge happen to lie on the line of a railroad. Provision has been made for a lock in the dam capable of receiving the largest vessels used upon the river; and it is obvious that commerce directed to the upper portions of the stream would gain much from the power to ascend the river independently of the rise and fall of the tide. Vessels which might have occasion to be moored at the wharves on the river above the dam would find in this new condition of things the great advantage of floating at all times. How great this gain would be can be understood when it is stated that the river bed is practically exposed at the United States Arsenal at Watertown at low tide.

Estimates have been made for a dam to be 100 feet in width, and there would thus be provided a foundation for another roadway into the city of Boston from East Cambridge and the country beyond of permanent character, a means of approach to the city likely to be much needed when the time comes for the reconstruction of Craigie's bridge.

The landscape architect would also be able to connect this structure with the public lands on both banks of the river by such additional fillings and rounding of the corners as would materially increase the area of these grounds and add new features of attraction.

We cannot convince ourselves that the harbor will be noticeably injured by the loss of the large quantities of water discharged by the outgoing tide. The opinions of the experts who have from time to time examined the harbor have in recent years been considerably modified, possibly in view of the unimpaired value of the harbor, notwithstanding the great decrease in the water areas of the Charles River and other basins. If the river below the site of the dam is only to serve the purpose of conveying the waters of the Charles and Miller's rivers to the sea, such diminution of its area as has already taken place will be of little consequence, for a smaller channel than the present would be sufficient to carry all that the Charles River alone could ever empty into it.

The more certain formation of ice on the basin created by the dam ought not, in the absence of any considerable amount of winter

commerce on the Charles, to be anything but favorable to the use of this stretch of several miles of river for skating, one of the best of winter exercises and sports. The probable more ready freezing of the channel of Boston Harbor below the dam would be an inconvenience if the constant movement of tugs and ferry boats were not quite certain to break up the ice almost as soon as formed.

The fear is often expressed that such basins as this may become, by reason of an insufficient current and the accumulation of organic matter in them, sources of nuisance and a menace to the public health. The statistics contained in the engineer's report show that there will be a very considerable movement of this sheet of water, and with the improvement in the quality likely to follow the operation of the new metropolitan sewer but little danger of such contamination of the water or such accumulation of filth on the bottom of the basin as could produce offensive smells or conditions dangerous to health. But should the unexpected, nevertheless, happen, the openings in the dam would easily allow of the admission of such quantities of salt water as would keep the basin in a perfectly satisfactory condition by establishing in it a very considerable circulation at each tide. We are fortunately, however, not without examples of basins quite similar to this, situated also in the midst of large populations, and in the most conspicuous example, the world-renowned Alster Basin, the water park of the city of Hamburg, there is no means of introducing any water beyond that flowing in the comparatively insignificant Alster. This basin is very shallow and has a muddy bottom, but is surrounded by some of the best private houses of this flourishing and wealthy port, and the water surface of the basin and its shores constitute the most frequented places of resort in the city. During the terrible cholera epidemic of 1892, when Hamburg suffered, as few European cities ever have suffered, from this pestilence, the wards in which lie the Alster Basins showed the lowest death rates in the city. We do not intend to say that cholera spreads only where there is filth, but it is true that the conditions among which it finds its widest extension are those of unsanitary surroundings.

There is no question probably in the mind of any sanitary observer that a river of moderately pure water flowing at a constant level between clean banks is much to be preferred to a similar stream which is subject to a rise and fall of many feet twice in the twenty-four hours. Streams of the latter description constantly deposit upon

the banks the material floating on the surface, material that occasions little offence while surrounded and saturated with water, but rapidly decays when exposed to the sun and air upon the shores of the river.

Whatever care may be taken of the Charles River in the time to come, if it remain an estuary, there is no doubt in our minds that the banks, sloping as now to the stream, will be more or less a nuisance; dwellings will, so far as possible, not be erected in its neighborhood, or, if they are built here, will be of the sort which are compelled to seek undesirable, consequently cheap, land. A population will be established here which will resist most obstinately and naturally the destruction of their homes, and one more, and perhaps the greatest, opportunity to permanently improve the incomparable situation of Boston and its suburbs will have passed away.

In order to protect the low-lying portions of the territory within the valley of this portion of the Charles River, it has seemed advisable to us to make the permanent level in this basin somewhat lower than that of ordinary high tides. The level which seems most advantageous is that of two feet and six inches below such tides. It is well known that exceptionally high tides have done much injury throughout the estuary of the river, both by flooding and by interference with sewers, and we may reasonably expect that still more will be occasioned on account of the increased occupation of these low lands whenever we again have such tides as that which occurred at the time of the destruction of the Minot's Ledge light-house in 1851, or, indeed, tides of much lower height. The forlorn marshes that now border upon the river would become, without the expenditure on them of a dollar, fertile meadows, scarcely needing treatment to become attractive places for recreation; and capable, with treatment, of becoming scenes of great beauty, as the designs of the landscape architects so clearly show. Some solicitude has, in recent years, been manifested in regard to the preservation of the piles upon which are placed the foundations of so many valuable buildings in the Back Bay district of Boston. The maintenance of a basin at a constant level considerably above that at which, by city ordinance, these piles are cut off will probably increase the security of such substructures. We believe that the amount of organic or putrescible material at present deposited on the banks and bed of the river need not present any serious obstacle to the carrying out of this plan. The completion of the whole design will be a matter of years, the addi-

tion of the most serious kind of pollution, sewage, will cease, probably, in the course of a year, the narrowing of the stream in the present basin is rapidly going on, with consequent dimunition of deposit, and whatever remains after this will be profitably removed to the banks of the stream for such fillings as may be necessary to prepare the river for its new functions.

Whatever plan is adopted for the future treatment of the river, it seems to us essential that all the lands indicated on the plan presented by the landscape architects should be at once acquired. The mere fact that it was public property would alone, we think, improve the value of all the adjoining lands to such an extent as to make the purchase a wise business transaction.

The lowering of the grade of the water in the proposed basin below high tide would help the city of Cambridge to an easier solution of a question which will sooner or later require the expenditure of large sums of money. The freight line of the Boston & Albany Railroad to East Boston now crosses all the main roads leading from Cambridge to Boston. A separation of grades, when this becomes necessary, will be very expensive; depressing the railroad tracks to such an extent as to allow the streets to remain unchanged is impossible; the present grade of the railroad crossing on Main Street, Cambridgeport, is about six feet above ordinary high tide. When the water level in this basin is reduced by two feet and a half it is clear that a lowering of the tracks can then be made, which will very materially reduce the cost of elevating the half dozen or more much travelled avenues now crossing the railroad at grade.

We now call your attention to the plan proposed by the landscape architects (page 36 of this report). Your board has not thought it advisable, at the present time, to recommend any additional taking of land on the Cambridge side of the river below West Boston bridge. Cambridge has recently acquired an extensive water front between West Boston and Craigie's bridges for park purposes, but the remaining portions of this frontage are occupied for commercial uses, and have quite recently been improved by the expenditure of large sums of money. The consequent enhancement of value leads us not to approve of this recommendation of our landscape architects, the more especially as the strip of land taken by the city of Cambridge does not appear to have been acquired with the intention of making it a portion of a continuous parkway.

By chapter 435 of the Acts of 1893 permission has already been

given to the city of Boston to construct on her side of the Charles River, beginning at West Boston bridge and ending at the Back Bay Fens, an embankment of a width not to exceed, in the rear of Beacon Street, one hundred feet, but subject to the condition that the filling thus made "shall not be used for building purposes, or for any other purpose than for ornamental grounds and a parkway."

The description in this act of the line to be followed in making the filling of the first section of the proposed embankment, that from West Boston bridge to the rear of Beacon Street, provides a broader margin than seems to us necessary on this side of the basin. We propose that so much of the act as relates to the filling on the easterly side of the basin and in continuation of the Charlesbank be so amended that the filling authorized shall not exceed 150 feet until the intersection with a line perpendicular to the harbor line at the southerly line of Mt. Vernon Street; thence continuing southerly and westerly on a curved line to the embankment in the rear of Beacon Street, to be hereafter described.

It may fairly be inferred from a careful examination of Plates VIII. and IX. that the owners of estates on the north side of Beacon Street west of Otter Street have no very great interest in the appearance of their houses and outbuildings as seen from the basin or the bridges crossing it. Whether this new basin will be attractive enough to induce the owners of these properties to so far change the external appearances of their houses as to make them worthy adjuncts to the superb location offered to them is a question which we find it difficult to answer. And yet upon the answer to this question really depends the solution of one of the most serious problems in connection with the improvement of the basin. We believe that this water park, if formed in accordance with the plans submitted, deserves surroundings of a character equally dignified and attractive with itself.

Two views of the problem present themselves to us: —

First. To advise the filling, to the north of the passageway in rear of Beacon Street, of a wider strip than that of 100 feet now authorized by chapter 435 of the acts of 1893, but not to exceed 150 feet; in the expectation that gradually the hoped-for improvement in the abutting estates will be effected.

Second. To recommend the construction of a wider embankment than that provided for by existing legislation, in order that a portion of the land so filled may be prepared for building sites.

After due deliberation we have concluded to present a plan for your consideration in accordance with the second view above stated.

It does not seem probable to us that the houses now standing on Beacon Street below Otter Street are likely to be adapted to the surroundings of the new basin; the large sums of money already spent upon their Beacon Street fronts would seem to preclude the change; moreover, these fronts to the south have always commanded higher prices than similar lots on the opposite side of the street, and the preference will undoubtedly be maintained. But it does seem to us essential that the houses situated on the borders of the basin should also front upon it, not only for the adornment of the basin, but also for the benefit that would accrue to it from the better policing and care which all public grounds receive when the neighboring householders walk through them habitually, or constantly have them under view. The back alley which now runs along the border of Charles River in the rear of Beacon Street would undoubtedly be well kept and inviting, where it is now neglected and repulsive, if the owners of the adjacent properties ever themselves made use of it.

The sale of the land prepared for building sites, if carried on as successfully as such transactions have hitherto been by the Commonwealth, would yield a large sum of money to be devoted to the repayment of the expenses of improvements herein recommended.

We, therefore, propose that, instead of a strip of ornamental ground in the rear of Beacon Street of a width not to exceed 100 feet, provision be made by which the Board of Harbor and Land Commissioners may be authorized to cause to be filled a space to the north of the present wall in the rear of Beacon Street not to exceed 300 feet in distance therefrom and extending in a line parallel therewith to the westerly line of the Back Bay Fens. One hundred and twenty feet in width of this, immediately to the north of the existing alleyway, to be filled to a grade proper for house lots, so much thereof as may be needed for streets and public open spaces to be reserved and the remainder to be sold. The money received therefor to constitute a fund, from which shall be defrayed the cost of building the dam, making the necessary fillings, and of such other expenses as may result from carrying out the plan of improvements herewith submitted. The remaining strip of 180 feet in breadth to be prepared in accordance with designs to be furnished by the Board of Park Commissioners, and to be used only for parkways and ornamental grounds.

It will be noticed that we recommend a somewhat wider strip in the rear of Beacon Street between the building line and the water than is designated on the plan of the landscape architects. We do so for the purpose of having a wider belt of trees and shrubs than has been thought by them to be necessary. Though the rapidly approaching use of the opposite Cambridge shore for building purposes will have a tendency to break the force of strong winds from the northwest, it is desirable to have a plantation, if only of shrubs and small trees, to still further diminish their force. The shore line of the basin above the Back Bay Fens and up to the Cottage Farm bridge on the Boston side of the river should also, in our opinion, be moved to the north. Whether the additional territory so gained should be used partly for new building sites or for purely ornamental grounds has been a subject of some difference of opinion between your commission and the landscape architects. The latter advise the creation of new building lots in addition to the ornamental grounds. We think that it is not advisable to narrow the stream at this point further than may be necessary for procuring the ornamental grounds alone. Our recommendation is that the harbor line be removed to the north a distance of 150 feet, from the Back Bay Fens to the new bridge drawn upon the plan, and above this bridge gradually narrowing till it reaches a width of 50 feet at the Cottage Farm bridge; that this new territory be connected with the filling in the rear of Beacon Street by appropriate curves, and be prepared for park uses by the Harbor and Land Commissioners in accordance with plans prepared by the Park Commissioners.

With the exceptions thus noted we are in cordial agreement with the recommendations of the landscape architects, whose advice we have sought, and therefore urge the prompt acquisition of all the lands indicated upon their plan, by means of legislation similar to that already employed by the Metropolitan Park Commissioners under authority of chapter 407 of Acts of 1893.

We are aware that some of the changes which have been advised by us may meet with much opposition from those who have interests in the houses on the northern side of Beacon Street below Otter Street. We have, therefore, endeavored to ascertain whether this situation had a value that could be measured by the valuations on the books of the assessors of the city. A result of the comparison of relative values on three of the principal residential streets of the Back Bay is here given.

Assessed Value of Land on Back Bay Streets, excluding Corner Lots.

Block.	Name of Street.	South Side. Rate per Sq. Foot.	North Side. Rate per Sq. Foot.	Ratio.
Arlington St. to Berkeley St., .	Commonwealth Ave.,	$6 58	$8 36	130
Arlington St. to Berkeley St., .	Marlborough St., .	4 45	4 75	107
Arlington St. to Berkeley St., .	Beacon St., . . .	5 00	5 75	116
Dartmouth St. to Exeter St., .	Commonwealth Ave.,	6 03	8 03	133
Dartmouth St. to Exeter St , .	Marlborough St., .	4 05	4 46	110
Dartmouth St. to Exeter St., .	Beacon St., . . .	4 48	5 50	120

It appears from this table that the difference in values, excluding corner lots, between the two sides of these three streets, respectively, while somewhat greater on Beacon Street than on Marlborough Street, is much less on Beacon Street than on Commonwealth Avenue. The Beacon Street lots are deeper than those on Commonwealth Avenue, and, perhaps, have a somewhat smaller value per square foot on this account than they would otherwise have, notwithstanding the fact that the owners of houses on the north side of Beacon Street are enabled to have stables on their own lots. When we consider the hardships that may appear to be inflicted upon owners of property on the water side of Beacon Street, who will lose the views over the river and the direct action of the breezes from over the water surfaces, we have also to remember the many thousands who will enjoy this breathing place and the attractive shores during the four months or more when the houses on Beacon Street are deserted by their owners.

What the value of the land to be created by this improvement would be we do not venture to estimate; opinions of those familiar with such matters vary widely; one or two persons have even asserted that the land would have no value above the cost of the filling; but, inasmuch as the city of Boston already has under consideration the making of an embankment, as provided for by chapter 435 of the Acts of 1893, we have only to estimate the expense of filling a strip 120 feet wide. This admits of accurate calculation, and could be done for less than fifty cents a square foot. Whether the new land would have a greater value than this is a question which all would answer, we think, in the affirmative.

The lowest value of the new land, estimated by those who have attached any value to it, is sufficient to cover all the expenses of the

dam and the making of the land. If some of the higher estimates were taken it might safely be assumed that all the land which is included in the taking recommended for metropolitan park purposes could be procured without inflicting any burden upon the metropolitan district.

Mayor Mathews, in an inaugural address delivered in the year 1891, before the city council of Boston, used the following words: —

> We have in this basin the opportunity for making the finest water park in any city in the country; an opportunity which should be grasped before it is too late.
>
> The eventual solution of this whole problem should, I think, be an imitation of the plan adopted by the city of Hamburg, under similar circumstances. We should dam up the stream at the narrowest point between Charlestown and Boston, and lay out a series of parks and boulevards along the basin thus created.

We have incorporated in this report copies of photographs showing various aspects of the Alster Basin in Hamburg. They tell their story so effectively that minute description is hardly needed. Hamburg lies on the east bank of the Elbe, at a distance of seventy miles from the German Ocean, and is the most important commercial city of the German Empire. The population of the city and suburbs exceeds 600,000. The climate is harsh and fully as much exposed to cold and disagreeable winds as Boston is. The thermometer does not indicate so low degrees of temperature, but the difference between the two cities in this regard is not very great. In former times the Alster was a small stream flowing through the centre of the city and entering the Elbe at right angles to the latter's course. At the entrance of the Alster into the Elbe an estuary was formed which sheltered the small vessels engaged in the commerce of those days.

With the growth of the city larger and more convenient docks were formed on the Elbe; and the formation of the Alster Basin was begun at a point about a mile distant from the entrance of the Alster into the Elbe; dams across the stream were constructed with suitable contrivances for the passage of mastless vessels.

Constant improvements have been going on in this water park, some the results of the needs of a growing city and some from efforts to increase the attractions of the basin and its borders. There are two basins, an upper and a lower, separated by the bridge shown in Plate No. III.

The views Nos. I. and II. present scenes upon the lower basin. About this are ranged some of the finest of the private houses, the principal hotels, and such shops as are usually found in the better quarters of a city.

Plate IV. is a view across a portion of the upper basin, looking into the city and towards the bridge which separates the two basins.

It will be noticed that the lower water park is treated in a formal way with walls, straight lines of street, and rows of trees; in the upper basin walls are replaced by beaches; the shore lines no longer run parallel to the streets, and the trees and shrubbery are grouped in effective masses. At points more distant from the city and on the upper reaches of the river, very little attempt has been made to improve the naturally pleasing variation of banks but slightly elevated above the stream and verdant meadows interspersed with trees, shrubbery and gardens.

We desire to call attention to the evidences of appreciation of all those charms shown by the life everywhere manifest, — the little steamer makes its rounds from one point to another on the water park; row-boats are plenty, and when some much-frequented place of resort on the stream is reached, as shown in Plate V., the popular enjoyment of it all should convince this community that much labor and expense could be profitably invested in procuring for the metropolitan district the opportunity for the same innocent enjoyments. We have a framework for such scenes far superior to that possessed by Hamburg, and the expense of preparation is not excessive.

That all this out-door life is not peculiar to the German nation is well shown by the illustration Plate VI. (from report of Metropolitan Park Commissioners, 1893), of boating on the Thames. Nothing of all this has hitherto been possible in the estuary of the Charles, although some suggestion of the possibilities in this direction may be obtained from the rapidly growing use of the comparatively inaccessible fresh-water basin farther up the stream extending from Waltham to Riverside. The repulsive appearance of the shores of the estuary at the lower stages of tide, the foul odors along its banks and flats, and the difficulties experienced in passing under the low bridges at high tide, have combined to make boating and the use of the stream by small steamboats unattractive and, in a measure, dangerous.

In conclusion, your board feels that no treatment of the Charles River can be entirely satisfactory which does not regard the condition

of the river above and in Waltham. At the boundary of that city, by the terms of the act under which we are directed to make our investigation and report, our labors end.

We have not thought that it was necessary to submit herewith the drafts of such legislation as might seem to be required for carrying out our recommendations. We are aware that the very serious changes proposed require the co-operation of the United States, the State and various municipalities. But the questions only differ in degree from some which have already been satisfactorily determined by existing commissions whose organizations are sufficiently complete to enable them to promptly undertake the execution of so much of these plans as it may seem wise to the Commonwealth to enter upon.

HENRY P. WALCOTT,
Chairman.

PHILIP A. CHASE,
WILLIAM B. DE LAS CASAS,
ABRAHAM L. RICHARDS,
Board of Metropolitan Park Commissioners.

HIRAM F. MILLS,
FRANK W. DRAPER,
JOSEPH W. HASTINGS,
GERARD C. TOBEY,
JAMES W. HULL,
CHARLES H. PORTER,
State Board of Health.

BOSTON, MASS., April 27, 1894.

WATER SUPPLY

AND

SEWERAGE.

ADVICE TO CITIES AND TOWNS.

WATER SUPPLY AND SEWERAGE.*

[Report required by the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage."]

The following report contains the substance of the replies made by the Board to those cities, towns, corporations and individuals which have applied to the Board for its advice relative to systems of water supply, drainage and sewerage, under the provisions of chapter 375 of the Acts of 1888. It also includes a summary of the work done by the Board in connection with the examination of water supplies and rivers, and the purification of sewage.

The chemical and microscopical analyses of the water supplies and rivers of the State have been continued during the year 1894, 2,006 samples having been examined. The number of examinations of waters proposed for new supplies of cities and towns is constantly on the increase, the analyses of this character being more numerous during the past year than ever before. Following is a classified list of the waters examined during the year: —

From open and covered reservoirs for the storage of ground waters, .	29	
From ground-water supplies, ...	384	
Special investigations of regular water supplies affected by tastes, odors, etc, ...	23	
From ponds and storage reservoirs and their inlets, ...	755	
From streams and miscellaneous sources, ...	63	
Total from regular water supplies, ...		1,254
In connection with investigations of new sources of water supply, . .	358	
With reference to pollution of streams, ...	107	
With reference to sewage purification at Framingham, Marlborough, Gardner, Medfield and Amherst.	152	
In connection with a study of deep wells in Boston and vicinity, . .	50	
In connection with the study of epidemics, ...	7	
Miscellaneous, ...	78	
		752
Total, ...		2,006

* The first pages of this report were contained in a report made to the Legislature Jan. 10, 1895 (Senate Document, No. 48). A portion of the report then made, relating to the work done at the Lawrence Experiment Station, is not reproduced, because a more complete account of the work done at this place will be found in a subsequent part of this volume.

The microscopical analyses of the waters have added to our information of the organisms occurring in surface waters, and work has also been continued on the connection between the taste and odors of waters and the organisms which they contain.

In previous reports of the Board repeated mention has been made of the occurrence of iron in many ground waters in excess of the amount which can be held in solution after the water has been exposed to the air. Owing to the prolonged period of low rainfall, these occurrences of excessive amounts of iron in ground waters have been more frequent, and some surface waters, also, have been found to contain an unusual amount of iron. Iron-containing ground waters have, in some localities in this country, been successfully treated by aeration and filtration, and the iron by this means nearly or completely removed. Such methods are, however, only practicable where the iron exists as carbonate. When the iron is in the form of sulphate or where the water contains much organic matter, the complete removal of the iron, without chemical treatment, has been found to be a matter of much greater difficulty.

During the past year there have been analyzed waters from many deep wells in Boston and vicinity. These wells vary from one hundred to over six hundred feet in depth, and are mostly private property, the water being used in many industrial operations. The water from these wells is generally characterized by the presence of much mineral matter, and, as a rule, by little organic matter. Many of these waters show the influence of surface drainage and of high sewage pollution. The purification has been in most cases, however, very nearly complete, as far as organic contamination is concerned. Many of them show direct contamination with sea water by their high contents of salt. In addition to the usual sanitary examination of these deep well waters, the principal mineral ingredients have also been determined. These very complete analyses are of great interest, not only from a sanitary point of view, but also from the stand-point of the industrial uses of these waters, and further of their relations to the geological strata in which they occur.

The analyses of the sewage and effluents from the various sewage fields throughout the State have been continued during the past year, and additional information obtained as to the continued efficiency of these fields.

During the present year it is intended to make an extended study of the nature of the coloring matter in surface waters by means of an instrument which enables us to analyze the color. It is hoped that, apart from the scientific results of this examination, we may obtain valuable information as to the relation between the colors of waters and the character of the organisms which this organic coloring matter can support.

ADVICE TO CITIES AND TOWNS.

Under the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage," the Board is required "from time to time *to consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply, drainage or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their drainage or sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby.* It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or sewage from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or sewage: *provided,* that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purposes of this act. *All such authorities, corporations,*

firms and individuals are hereby required to give notice to said Board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water supply and disposal of drainage and sewage; and all petitions to the Legislature for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of the said Board thereon."

During the year 1894 the Board has given its advice to the following cities, towns, corporations and individuals who have applied for such advice under the provisions of the general act of 1888, or under special acts relating to water supply and sewerage.

Replies were made during the year to applications made from the following sources for advice relative to water supply: Arlington, Barre, Belchertown, Blackstone, Brockton, Brookfield, Dudley, Gloucester, Greenfield, Hingham and Hull, Holyoke, Hyde Park school committee (two replies), Hyde Park Water Company, Ipswich, Longmeadow, Milford, Milton, Monson, New Bedford, Newburyport (city), Newburyport Water Company, North Attleborough, Norton, Quincy, Swampscott, Wareham (Onset Bay Water Company), Watertown, Westborough Lunatic Hospital, Westport (Water Supply of Horse Neck Beach) and Winchendon (four replies).

Replies relating to sewerage and sewage disposal were made, in answer to applications from the following sources: Andover, Concord, Haverhill, Hudson, Milton, Nantucket, North Andover and Palmer.

Replies were also made during the year relative to the subject of pollution of streams and water supplies, to certain authorities and other parties in the following towns: To H. B. Cottle, Esq., of Brookfield, in regard to the discharge of sewage by the town of Spencer into the Quaboag River; to the selectmen of Deerfield relative to the pollution of the Green River by the town of Greenfield; to the water board of Rockport relative to the pollution of Cape Pond by a glue factory on its water-shed; and to citizens of Worcester relative to the protection of one of the reservoirs from pollution.

Water Supply.

The following is the substance of the action of the Board in reply to applications for advice relating to water supply : —

Arlington. An application was received from the committee on water supply of Arlington, April 27, 1894, stating that the committee had continued their investigations, as previously suggested by the Board, and at the same time asking the advice of the Board relative to the same. The Board replied as follows : —

May 25, 1894.

The State Board of Health received from you an application dated April 26, 1894, stating that since the reply made by this Board to you on Feb. 10, 1893, you had continued your investigations, and that you now asked if, in view of the additional information which you had obtained, the Board had any additional advice to give you. Your application was accompanied by two printed reports of your committee to the town of Arlington, one dated Feb. 21, 1893, and the other Feb, 26, 1894. The first of these reports contains the reply of the Board above referred to, and the other the results of subsequent investigations.

By tests of the ground at various points within the water-shed from which the present supply of the town is derived, you have found no place likely to furnish as good a supply of water as the source tested last year, on the border of the Great Meadows near the East Lexington railroad station. At this place you have driven a few additional wells, and have made tests to determine the capacity of the source by connecting the wells together and pumping from them from Dec. 1 to Dec. 29, 1893, at an average rate of about 500,000 gallons per day. During this test you sent three samples of water to this Board for analysis. The samples were collected on Dec. 14, 19 and 27, 1893. The analyses gave substantially the same indications as those made a year before, and, like them, they showed a perceptible deterioration in the quality of the water during the progress of the test. The quality of the water at the time of the test was such that it would be satisfactory for all water supply purposes, but there is reason to think that it will deteriorate if a large quantity of water is pumped from this source.

The tests of this year show more definitely than those of last year that quite a large quantity of water can be obtained from

this source, but they do not give additional information of such a character as to cause the Board to change its views, as expressed in its previous reply, as to the limitations of this source in a dry year.

The conditions under which you now apply for the advice of the Board are somewhat different from those of last year. You then had in view the construction of permanent works, and you now indicate that it is proposed to put in works of a temporary character for pumping water from these wells until a metropolitan water supply is available. Having in view the temporary character of the proposed works and the unfavorable results of investigations for obtaining a better water supply at some other point, the Board thinks that you cannot do better than to adopt this source. It is the general experience that the amount of water to be supplied for the first few years after the construction of works is comparatively small, and it is probable that this source will furnish all of the water needed for a temporary supply; moreover, the smaller the amount of water pumped, the less likelihood there is of deterioration in the quality of the water. It may be well to add that in referring to the possible deterioration in the quality of this water the Board has had in view the possibility that it might become unsuitable for laundry uses and unpalatable, rather than that it might become unwholesome.

BARRE. George A. Brown, and others, afterward incorporated as the Barre Water Company, applied to the Board April 7, 1894, for its advice relative to taking the water of certain springs in that town as a public water supply. The Board replied as follows: —

APRIL 27, 1894.

It is understood that you have had surveys made, which indicate that it will be feasible to collect the water which flows from a drainage area of two hundred and seven acres at a sufficient elevation above the town to supply water to it by gravity, but that the method of developing this source has not yet been fully decided upon.

Samples of water collected April 12, 1894, from the streams which flow from this territory, have been analyzed, and were found to be very soft and of very good quality for the purposes of a public water supply. The quality of the water to be obtained from this source for the supply of the town would depend to a considerable extent upon the method of taking the water. If it should be obtained from the ground by means of a collecting well and collecting ditches or pipes, and conveyed to the consumers without

being exposed to the light, it would be much better than if stored in a reservoir.

With regard to the quantity of water, it is not feasible to tell with certainty from the present information whether a sufficient supply can be obtained from this source or not; but the prospects are favorable, and the Board would, therefore, advise further investigation of this territory in order to determine if a sufficient supply can be obtained from the ground. If a ground-water supply should be obtained and should prove insufficient in the future, it might be supplemented by the construction of a storage reservoir above the place where the ground-water supply is taken. When you have more definite plans to present, the Board will advise you further in this matter, if you so desire.

Belchertown. An application was received Feb. 7, 1894, from the water committee of Belchertown, for the advice of the Board relative to the propriety of taking the water of Jabish Brook and of Chambray Brook in Belchertown as sources of water supply for the town. The Board replied as follows: —

March 1, 1894.

The Board has caused these brooks to be examined and their waters to be analyzed. The analyses of samples of water collected on Feb. 19, 1894, show that the waters of both sources were very soft, and free from any excessive amount of organic matter. The waters had a somewhat high color, probably owing to previous contact with vegetable matter in swampy places; but the color is not higher than that of many other waters used for water supply purposes in the State. There was not very much difference between the two waters, but in several respects the water of Chambray Brook was somewhat better than that of Jabish Brook.

The quality of the water of these sources would vary somewhat from time to time throughout the year, and might become worse if the water should be stored in storage reservoirs from which the soil and vegetable matter has not been removed; so that, before choosing either one or the other on account of the quality of the water, it would be desirable to have the results of further analyses and to know the character of reservoirs to be built above the proposed points of taking.

With regard to the quantity of water to be obtained from these sources, it may be said that Jabish Brook at the proposed point of taking would, with only a very small reservoir, furnish all the water that Belchertown would require, unless the flow of the stream in summer should be controlled by some large reservoir built by

the city of Springfield; in which case, if the gates were closed, there might not be a sufficient quantity of water.

Chambray Brook above the point where its water can be taken to Belchertown by gravity can be made to furnish a sufficient quantity of water for Belchertown by building a reservoir to store some of the surplus water in the spring of the year for use during the dry portions of the year.

With the present information the Board cannot advise definitely as to which of the two sources is the better one for the water supply of Belchertown; but it is obvious that, if they are found upon further investigation to be of nearly equal merit, having due regard to quality, quantity and cost, the supply should be taken from Chambray Brook, so as not to interfere with the water supply of the city of Springfield, which is now taken from Jabish Brook.

Blackstone. Francis N. Thayer and other citizens of Blackstone, who afterward obtained a charter as the Blackstone Water Co., applied to the Board Dec. 9, 1893, for its advice relative to taking the waters of Ironstone Pond and Emerson Brook, with their tributaries, in the town of Uxbridge, and also certain lands in the town of Blackstone for the purpose of driving wells in the same for a public water supply for the town of Blackstone, including the village of Millville. The Board replied to this application as follows: —

March 9, 1894.

The Board has caused examinations to be made of the proposed sources of supply, as far as has been found practicable in winter.

Ironstone Pond, the first of the sources named, was found to be an old millpond, formed by a dam built across Ironstone Brook. It is said to have an area of about 24.3 acres and an average depth of about 5.43 feet. Immediately above this pond is a reservoir which is said to have an area of 60.5 acres and an average depth of 4.2 feet. The water-shed, which is partly in the State of Rhode Island, is quite large, and with a moderate amount of storage will furnish all the water required for Blackstone for a long time in the future. Analyses of samples of water from this source showed that the water at the time the samples were collected was of fairly good quality for the purposes of a public water supply. It is not feasible to tell, however, from examinations made at this season of the year, what the quality of water stored in such shallow reservoirs will be in the hot weather of summer; and the Board cannot at the present time advise that this is a suitable source of water supply for the town of Blackstone.

Emerson Brook, at the point where it is high enough to supply water to the town by gravity, is a stream of sufficient size to provide, with only a small amount of storage, enough water to supply the present population of Blackstone; and, if storage reservoirs can be built upon it which will contain in the neighborhood of one hundred million gallons, it will supply the town for a long time in the future. Analyses of samples of water from this source showed that the water at the time the samples were collected was not very different from that of Ironstone Pond. The analyses indicated, however, both by the slightly higher color and the more noticeable vegetable odor, that the water of this brook was somewhat more affected by contact with vegetable matter in swamps and shallow reservoirs than the water of Ironstone Pond. There are some small and very shallow reservoirs upon this water-shed, and in this case, as in the other, it is difficult to predict at the present time whether or not the water will be of suitable quality for domestic use in the hotter portions of the year. If the required storage of the water could be effected by the construction of a storage reservoir of considerable depth, which had been properly prepared for the reception of water by the removal of soil and vegetable matter from its bottom and sides, and the present shallow reservoirs and swamps could be drained, a better water could be obtained from this source.

With regard to the other source mentioned by you, namely, a ground-water source within the limits of the town of Blackstone, it is not practicable at this season of the year and in the time within which you desire a reply to make a sufficient examination to ascertain whether there is a place within the town from which it is probable that a ground-water supply could be obtained. If a source could be found, away from the thickly settled portion of the town and not adjacent to the Blackstone River, from which a sufficient quantity of ground water could be obtained, it is probable that the quality of the water would be very much better than that of water from either of the other sources mentioned.

As already indicated, the Board cannot advise you definitely at the present time as to the most appropriate source of supply for the town; but will advise further, if you so request, later in the year, when analyses can be made of the water in the summer, and when you have more definite information to present as to the feasibility of obtaining a water supply from the ground, or as to the character of storage reservoirs which can be constructed.

Brockton. An application was received from the city engineer of Brockton May 1, 1894, relative to increasing

the water supply of the city and providing for certain districts requiring a high-pressure service, and also suggesting the future possibility of a district supply embracing other contiguous towns. The Board replied as follows: —

SEPT. 20, 1894.

The State Board of Health has considered your application dated May 1, 1894, and the amendment thereto dated July 20. In this application you state that you have been directed to report plans for supplying Brockton Heights and Cary Hill with water, and that these localities have so great an elevation that they cannot be supplied with water from the present service.

You also suggest that, as the present source of supply may prove inadequate in the near future, owing to the growth of the city, and the probable increase in the consumption of water due to the construction of the sewerage system now under way, it may be wise for your recommendations to be in line with or a part of a contemplated water supply for Brockton and towns in its vicinity. As possible sources of additional supply, you refer to the construction of a new storage reservoir below the present one, as a source within the city, and to Silver Lake as being apparently the best source beyond the city.

Upon comparing the consumption of water in Brockton with the capacity of the present source in a dry year, it is found that the ultimate capacity is more than twice the present average daily consumption, which shows that there is no immediate need of a new supply on account of the quantity of water. It is, however, the general experience that the amount of water consumed increases much more rapidly than the population; and the facilities offered by the new sewerage system for removing the waste water are likely to lead to the more liberal use of water in the future, so that it is not improbable that the present source may prove inadequate before many years.

Increasing the supply of the city by the construction of a reservoir below the present one does not seem advisable, on account of the large cost of a properly prepared reservoir at this place in proportion to the additional quantity of water to be obtained, and because the water, being derived mainly from the water-shed now used, would not be of the best quality; moreover, the reservoir is not so far from the settled portions of Brockton but that its waters are liable to be polluted in the future, unless considerable expense is incurred to prevent the occupation of the land draining toward the reservoir.

Silver Lake seems likely to be the best future source of supply for Brockton, on account of the more ample quantity of water which it will furnish, the superior character of the water for water supply purposes, and the better opportunities for supplementing the supply when the amount of water which this lake will furnish is exhausted. As the town of Whitman needs a better supply than it now has, and has already obtained the right to take water from Silver Lake, there is no doubt that it would be for the pecuniary advantage of both Whitman and Brockton to construct works jointly, rather than to construct independent works. In regard to other towns near Brockton, the advantages of joint action are not obvious, although further investigation may show that it is desirable in some instances.

The question of a high-service supply has been considered with reference to the possibility of taking the future supply from various sources which have been suggested; and it has been found that the source of supply would not have any considerable influence upon the design of a system of high-service works controlled wholly by the city of Brockton, because the best plan in any case appears to be to maintain the present pressure in the greater part of the city, and to add a higher service for Brockton Heights and Cary Hill, to be supplied by pumps located at the present pumping station.

BROOKFIELD. The town of Brookfield requested the opinion of the Board Sept. 15, 1894, relative to the quality of the water of Quaboag River as a temporary water supply for the town, stating that the public supply had failed, and that recourse had been had to this stream. The Board replied as follows: —

SEPT. 25, 1894.

The State Board of Health has received from you a communication dated Sept. 15, 1894, in which you state that it is your intention to use, temporarily, the water of Quaboag River for the water supply of the town of Brookfield.

From the information already in the possession of the Board with regard to the amount of sewage and other polluting matter which enters the Quaboag River or its tributaries, the Board is of the opinion that this water is not of suitable quality for a domestic water supply, and that if for fire protection and other purposes than drinking you find it necessary to pump this water into the pipes, you should notify each water taker that it is dangerous to drink the water.

DUDLEY. An application was received April 2, 1894, from D. W. Crosby of Webster, for the advice of the Board relative to extending the water pipes of the Webster water supply into a village of Dudley which lies in close proximity to the town of Webster. The Board replied as follows: —

APRIL 5, 1894.

The State Board of Health received from you on April 2, 1894, an application for advice relative to a proposed water supply for portions of the town of Dudley, in which you state that you propose to ask the Legislature to grant the town of Webster, Mass., permission to lay water pipes in a part of Dudley known as Merino Village, to furnish a supply of water for domestic and other purposes to the citizens of Dudley who may desire the same.

The Board has on two occasions advised the authorities of the town of Webster with regard to proposed sources of water supply, and in the communications to Webster, copies of which are given below (see twenty-second annual report of the Board, page 13, and twenty-fifth annual report, page 63), you will find the opinion of the Board with regard to the quality of the water if taken directly from Lake Chaubunagungamaug or from the ground near it (the present source of water supply of Webster); also its opinion as to the propriety of taking water from this source for the supply of portions of the town of Dudley.

The Board does not think it within its province to advise as to the agency by which the water should be supplied.

GLOUCESTER. An application was received from the city of Gloucester March 23, 1894, for the advice of the Board relative to taking a new water supply from the Chebacco lakes in the town of Essex. The Board replied as follows: —

APRIL 27, 1894.

The State Board of Health received on March 23, 1894, an application made by you in behalf of the city of Gloucester for the advice of the Board with regard to a proposed water supply for the city. In this application you state that the "proposed source of supply is the group of lakes in the town of Essex known as the Chebacco ponds," and that it is proposed to take the supply from Chebacco Lake, at a point near the north-westerly end.

The Board has caused examinations to be made of the Chebacco ponds and of the sources in West Gloucester from which water is now taken for supplying the city of Gloucester. It has also

examined into the opportunities for developing the present sources of supply and other sources near them.

The Board finds that the present sources have sufficient capacity in a dry year to supply the quantity of water now used by the city; but the population now supplied is much less than the total population, and the amount of water consumed is increasing from year to year, so that it will be necessary before long either to develop the sources now used or to obtain a further supply from other sources. If the present sources and those in their vicinity should be fully developed they would furnish fully double the quantity of water now used, and make a further supply unnecessary at the present time.

The water supplied from the present reservoirs of the Gloucester Water Company is practically free from pollution by sewage, and in other respects it is a fairly satisfactory water for the purposes of a public water supply, and is somewhat better at the present time than the water in Chebacco Lake. It could undoubtedly be improved, however, by the removal of stumps, soil and vegetable matter from the bottom and sides of the reservoirs. The water from other sources near the present ones in West Gloucester has not been analyzed, but from an examination of these sources it seems probable that they will furnish as good water as the sources now supplying the city.

Chebacco Lake will furnish a somewhat larger quantity of water than could be obtained from all of the available sources in West Gloucester if they were fully developed, and is probably the most available source of water supply for Gloucester, independent of the present works. As already indicated, the water is not quite as good as that now supplied to the city, and it is doubtful if it would prove a satisfactory water for water-supply purposes unless improved in some way, which cannot be determined with the information now available.

The Chebacco ponds are located in the towns of Essex, Hamilton and Wenham, and are only a short distance from Manchester, and may prove the most available source of water supply or additional water supply for these towns; moreover, it is not improbable that they may prove the most available source from which to take an additional water supply for Salem and Beverly, when the capacity of the sources from which these places are now authorized to take water has been reached. Under these circumstances, the Board is of the opinion that the Chebacco ponds are not at present the most appropriate source of supply for the city of Gloucester; and if rights in these ponds are granted to Gloucester, they should be limited by proper reservations for other places.

Greenfield. The water commissioners of Fire District No. 1 of Greenfield applied to the Board March 1, 1894, for its advice relative to increasing the water supply of the district by building a larger reservoir in the same water-shed now used by the district, or by taking an additional supply from Workman Brook in Colrain. The Board replied as follows: —

April 2, 1894.

The present source of supply is Glen Brook above the Glen, in the town of Leyden, where the drainage area of the brook is 5.36 square miles. This source has been developed by the construction of a dam at the Glen, which creates a storage reservoir containing about 16,000,000 gallons of water.

Judging the capacity of this source from the area of its water-shed and the size of the present storage reservoir, the works should be able to supply more than enough water for the population now supplied; and it may be that by moderate restrictions upon the waste of water or by stopping the leakage at the dam, if it is feasible to do so, the need of an additional supply may be avoided for the present.

If the present conditions of consumption of water and leakage at the dam are continued, it is obvious from the experience of last summer, when the reservoir was nearly emptied, that a further supply is required; and one of the plans suggested by you is to increase the storage capacity upon the water-shed from which the supply is now taken, by building a reservoir which will hold about 75,000,000 gallons, upon the east branch of Glen Brook, about one and three-quarters miles up stream from the present dam. The construction of a reservoir of this kind would undoubtedly increase the capacity of the present source to such an extent that it would furnish a sufficient quantity of water for the towns now supplied from it for a long time in the future.

A water as good as that now flowing in these brooks will deteriorate by storage in a reservoir in which the water stands without being renewed as long as it would in the proposed reservoir, so that it will be less palatable than the water supplied from the present reservoir; and it will deteriorate very much more if the soil and vegetable matter are not removed from the bottom and sides of the reservoir before it is filled than if they are removed.

Owing to the location of the proposed reservoir upon a branch brook where the water will not be renewed frequently, the water will not be in quite as good condition as if the reservoir were located upon the main stream; but there is a compensating advan-

tage in this location, that, since the main brook and existing reservoir will furnish the required amount of water under nearly all circumstances, it will not be necessary to take any large proportion of the water from the new reservoir, except on rare occasions during periods of extreme drought.

The water of Workman Brook has been analyzed, and, judging from the analysis and the character of the drainage area, it would be as good as the water from Glen Brook. Workman Brook, however, has a water-shed only about one-sixth as large as that of Glen Brook, and will not furnish any very large addition to the present water supply.

From present information it would not seem advisable to take an additional water supply from Workman Brook, because of the large expense when compared with the quantity of water to be obtained. It is possible, however, that further investigations may show that this is a desirable source to adopt, and it does not seem to be required for the water supply of any other community.

The Board recommends that you investigate more thoroughly the relative cost and merit of the plans which you have suggested for increasing the supply, and that you should also include in the investigation two other plans, one of which is to increase the storage capacity of the present reservoir on Glen Brook by constructing a higher dam at or just below the present dam at the Glen, and the other relates to taking an additional supply from Fisk Brook, which the fire district was authorized to take by chapter 247 of the acts of 1883. The analysis of a sample of water from Fisk Brook shows that it has the same general character as the water of Workman and Glen brooks, except that it is somewhat harder.

This reply is made at the present time because you desire it for use during the session of the present Legislature; and, as the investigations which you have thus far made have not been sufficiently extended to furnish definite information as to the relative merits of different sources, it is necessarily of a general nature. When you have further information to present the Board will advise you further in this matter.

HINGHAM and HULL. An application was received May 14, 1894, from the Hingham Water Company, for the advice of the Board relative to taking an additional water supply for Hingham and Hull from Accord Brook and Cushing's Pond in Hingham, at the same time calling attention to the existence of a bad taste and odor in the water of Accord Pond. The Board replied as follows: —

JULY 26, 1894.

The sources from which you now supply these towns are Accord Pond, which has an area of 98 acres and is 133 feet above mean high tide, and Fulling Mill Pond, which has an area of about 14 acres and is only 30 feet above high tide. Accord Pond supplies water by gravity, while from Fulling Mill Pond the water has to be pumped.

You state that it is proposed to take water from Accord Brook at a point about 500 feet above South Pleasant Street and about 3,900 feet east from Fulling Mill Pond, where the brook is about 62 feet above high water in this pond. You also state that Cushing's Pond is at about the same level as Fulling Mill Pond, and that it contains perhaps 30 acres.

In order to ascertain the quality of the water, these sources have been examined and samples of water have been collected from them and analyzed. The waters from both of them have the same general characteristics, in that they are comparatively free from contamination by sewage, since the water-sheds are both sparsely populated, and they both have a deep brownish color and contain a large amount of vegetable matter acquired from the swamps upon the water-shed. Owing to the swampy character of the waters, the Board is of opinion that they will not be of suitable quality for domestic use unless they are efficiently purified.

There are two ways of improving such waters, which are worthy of consideration in the present case. One is to drain the swamps so that the water will not stand upon them, nor come in contact with the mud and vegetable matter as it passes through them. It seems doubtful in the present case if it would be feasible to improve the character of the water in this way to a sufficient extent to render it satisfactory for water supply purposes. The other method of purification is by filtration. Owing to the very dark color of the waters, it does not seem probable that filtration through artificial sand filters would prove satisfactory, because the cost of filters large enough to permit the very slow filtration of the water which would be necessary to remove the color would be prohibitory.

The plan which seems likely to give the most satisfactory results is one in which the sandy or gravelly land near Fulling Mill Pond or Accord Pond would be utilized as a natural filter bed, by preparing its surface so that the water could be distributed over it. If the material is sufficiently porous, the water will soak into the ground and find its way gradually by percolation underground into these ponds or their tributaries.

The Board advises, as the first investigation in this line, that you should ascertain whether there is not high porous land near Fulling Mill Pond or the brook which feeds it where filter beds of the character above referred to can be economically constructed, and to which the water of Accord Brook may be conveyed by gravity through a pipe. It is, of course, necessary that these beds should be so located that the water after being filtered into the ground will find its way into the pond; and it may be necessary to construct ditches or other works for collecting the water after it is filtered and conveying it to the pond in such a way that it will not deteriorate by flowing through any rank vegetation.

The quantity of water which can be purified by filtration through natural beds in this way will vary with the local conditions; but our information leads us to believe that under ordinary conditions an average of 300,000 gallons per acre per day could be efficiently purified, provided there is an intermission in the operation of the filters as often as once in twenty-four hours.

It is desirable in any case that Fulling Mill Pond should be improved by the removal of all mud from its bottom; but if the plan above suggested should be carried out, it is even more desirable that this should be done, so that the filtered water would be less likely to deteriorate by being stored in it.

Accord Pond is shown by the records not to have filled within the last three years, and it is obvious that more water must be obtained from some other source. As an additional supply cannot be obtained by gravity, it will be necessary in the future to pump a greater proportion of the water used. It may be found that if Fulling Mill Pond is cleaned out, as suggested, so that its water will be of suitable quality for use at all seasons of the year, and the supply to this pond is increased by the method of filtration above described, it will be feasible, by pumping during a greater portion of the year, to fill Accord Pond every spring, and to avoid for a time the necessity for constructing a storage reservoir upon Accord Brook, or the taking of water from Cushing's Pond.

In addition to your request for advice with regard to an additional supply of water, you have called the attention of the Board to a disagreeable taste and odor in the water of Accord Pond in June of this year, and to the occurrence of a similar trouble in previous years, and have asked that the matter be investigated, with a view to ascertaining the cause of the trouble and the best means for preventing its recurrence. Investigations made this year show that the taste and odor were due principally to the presence of a minute vegetable organism called *anabœna*, which was found in great abundance either distributed through the water of the pond or floating upon the surface as a green scum. This

organism is seldom found in unpolluted natural ponds which have not been raised, but is frequently found in artificial reservoirs which have been filled with water without removing the soil and vegetable matter from their bottom and sides. It seems probable that the flowage of land from which the soil and vegetable matter were not removed, by the raising of the dam at Accord Pond, has caused or helped to cause the growth of these organisms, and that the removal of this organic matter to the extent that it may be removed when the pond is drawn to a low level would lessen the frequency of occurrence and the amount of this growth, if it did not entirely prevent it.

The improvement of a swamp adjacent to the pond, so that the water will not stand in it nor come in contact with the mud and vegetable matter as it passes through it, would, by improving the quality of the water entering the pond, have a favorable effect upon the quality of the water in the pond.

HOLYOKE. An application was received Jan. 18, 1894, from the water commissioners of Holyoke, for the advice of the Board relative to taking Munn Brook in the town of Granville as an additional water supply for the city of Holyoke. Further investigation of this source had already been made, as suggested by the Board in reply to a previous application. The Board sent the following reply: —

FEB. 1, 1894.

On Oct. 5, 1893, the Board, in reply to a former application from you, gave certain advice with regard to Munn Brook as a source of additional water supply for your city, and also referred to other sources which it thought should be more thoroughly investigated before making a final decision as to the source to be adopted. The results of the investigations which have since been made by your engineers, taken in connection with the examinations made by the engineers of the Board, lead the Board to conclude that Munn Brook is the most appropriate source from which to take an additional water supply for your city.

The investigations which you have made with regard to storage reservoirs upon the Munn Brook water-shed seem to show that it is feasible to utilize at least as much of the flow from this water-shed as can be carried to Holyoke through a twenty-four inch pipe; and this source, connected with your present supply by a twenty-four inch pipe, will furnish fully 9,000,000 gallons of water per day.

The question of the size of the connecting pipe, whether it should be twenty or twenty-four inches in diameter, has been again con-

sidered in the light of the information furnished by the report submitted by you. The estimates show that, if Holyoke should continue to grow with the same numerical increase in each five years as during the twenty years from 1870 to 1890, and the consumption of water per inhabitant should not increase to above ninety gallons, it would be a little cheaper to lay a twenty-inch pipe in the beginning, and supplement it in the future by another pipe when necessary; but if the city should grow as rapidly as Worcester, Lowell and Fall River grew after they had attained the present size of Holyoke, or if the consumption per inhabitant should increase, it would be much cheaper to lay a twenty-four-inch pipe in the beginning. These considerations have led your engineer to advise the adoption of a twenty-four-inch pipe in the beginning, and seem to warrant this advice. There are several other points in favor of a larger pipe, even before its full capacity is required to prevent a shortage in the water supply, the most important of which is that it would insure the filling of the present ponds every spring, while the smaller pipe would not, and would make it unnecessary to draw the ponds and reservoir to a very low level, with a consequent deterioration in the quality of the water.

The Board would again call attention to the following paragraphs in its last reply: —

"The Board has caused an examination of the water-shed of Munn Brook to be made, also an analysis of a sample of water collected from the brook near the proposed point of taking.

"These examinations indicate that the water is soft, and naturally of very good quality; but it is at present polluted at a few points by the discharge of sewage into it.

"This pollution should be stopped before the water is taken for use, and as an additional precaution it is desirable that the water should be diverted into Ashley Pond, rather than be allowed to run directly from the stream through the pipes into the city."

HYDE PARK. The school committee of Hyde Park requested the Board, Sept. 25, 1894, to make an examination of the water supplied by the Hyde Park Water Company. The Board replied as follows: —

OCT. 5, 1894.

In response to your request, dated Sept. 25, 1894, the State Board of Health has caused samples of water to be collected for analysis from faucets in various parts of Hyde Park, supplied from the Hyde Park Water Company's works, and the results of the analyses are enclosed herewith.

It is difficult to judge from an analysis of the water furnished by this company whether it is safe for drinking or not, owing to the fact that the company has under its control wells which furnish water of varying quality. It is probable that the water from nearly all of the wells of the company is to a large extent filtered river water, and as the river is a polluted stream, the safety of the water for drinking purposes depends upon the efficiency of the filtration.

Some of the wells, notably the starch factory well, referred to in a reply to your committee dated Sept. 1, 1892, and a portion of the wells in a group driven in 1893, which are referred to in a reply to the Hyde Park Water Company dated June 14, 1893, were found to furnish water which was not regarded as safe for drinking.

In reply to an inquiry from this office, the water company has stated that no water is now taken from these wells; but the Board has not made any recent examinations in sufficient detail to enable it to state that all of the remaining wells now furnish good water. The analyses of the samples of water collected from the faucets in town show that the water is not perfectly purified; but it is not feasible to tell from them whether the result is due to a slight deterioration in the efficiency of the purification of the whole of the water, or whether it is caused by the mingling of imperfectly purified water from a few of the wells with that from other wells which furnish a thoroughly purified water. In the former case, notwithstanding the slight deterioration in the efficiency of the purification, the water would be regarded as suitable for drinking purposes, while in the latter it might not be so regarded.

A copy of both of the replies of the Board above referred to is enclosed herewith. (See twenty-fourth annual report of the Board, page 15, and twenty-fifth annual report, page 200.)

The school committee again applied to the Board Oct. 30, 1894, asking whether, in its judgment, the water thus furnished by the water company was a safe supply "for the school children of Hyde Park for drinking purposes." The Board replied as follows: —

Dec. 6, 1894.

The State Board of Health received from you a letter dated Oct. 30, 1894, stating that you had received the communication of the Board, dated October 5, in answer to your request for tests of the water supplied by the Hyde Park Water Company, and that the school committee had instructed you to inquire whether, in the

judgment of the Board, it was safe to supply the school children of Hyde Park, for drinking purposes, with the water furnished by this water company.

The reply of October 5 contained as definite a statement of the conditions affecting the purity of the Hyde Park water as it was feasible to make. As you have probably learned already from this reply some of the wells under the control of the Hyde Park Water Company, which it is understood have not been used, furnish water of unsuitable quality for drinking, and the Board has no certain knowledge that all of the other wells furnish water of good quality; in fact, the analyses show that the water supply to the town is not perfectly purified at some seasons of the year, and the water must be regarded with suspicion.

The Board does not believe that, from the information now in its possession, it would be justified in giving an opinion that the water furnished by the Hyde Park Water Company is unwholesome; but there is an uncertainty as to the wholesomeness of the water during a portion if not the whole of the year, which leaves no question that it would be better to supply the school children with a water of known purity.

HYDE PARK WATER COMPANY. An application was received from the Hyde Park Water Company July 10, 1894, for the advice of the Board relative to the quality of "three six-inch driven wells located and to be located on land belonging to the company near the New York & New England Railroad in Hyde Park." The Board replied as follows: —

DEC. 7, 1894.

Samples sent in by you from one of these wells on June 14 and from another on June 30 had previously been analyzed with satisfactory results.

A visit was made to your works by one of the engineers of the Board on July 13, when water was being drawn regularly from these wells by the pump in the pumping station. The analysis of a sample of water collected at this time showed a slight deterioration in the quality of the water, and a sample collected in a similar manner a week later showed a still further slight deterioration.

In view of this change in the character of the water, the results of the analyses were sent you on July 27, accompanied by a communication calling attention to the change in the character of the water, and stating that the Board would defer making a formal reply to your application until it could make further examinations,

with a view to determining the character of the water after pumping had been continued for a longer time.

Six more analyses were made, from June 30 to September 4 inclusive, the water generally coming from either two or three of the first group of three wells. At different times during the month of September samples were sent in from each of three additional wells located about the same distance from the railroad as the first three, and a short distance further from your pumping station. In October and November, after all six wells had been connected, additional samples were analyzed. The changes in the mineral constituents of the water taken from these wells correspond nearly enough with the changes in the mineral constituents of the water of the Neponset River to show clearly that a considerable portion of the water from these wells comes from the river; and, as the river is a highly polluted stream, the purification should be very thorough. The later analyses, both from the first three and from all six of the wells, while they show a large degree of purification resulting from the filtration of the river water through the ground, do not show a sufficiently thorough purification to make the water safe for drinking purposes. The water is not at all times rendered wholly free from turbidity, sediment, color or odor, and the amount of organic matter left in the water is larger than it should be in a water filtered from a polluted source. The character of the water from these wells may vary somewhat with the season of the year, being better in the wet than in the dry season; but it is probable that with a continued draft upon the wells the water will grow worse rather than better in the future.

In view of all these results, the Board is of the opinion that the six wells examined cannot be depended upon to furnish a water of satisfactory quality for drinking purposes; and it recommends that you obtain some new source of water supply, unless you can obtain good water from the ground in the vicinity of your present pumping station, at a greater distance from the river than the wells driven by you this year and last.

Ipswich. The committee on water supply of the town of Ipswich applied to the Board Dec. 28, 1893, for its advice relative to taking Dow's Brook in Ipswich as a public water supply; this source to be supplemented when necessary with water from Bull Brook. The Board replied as follows: —

Feb. 1, 1894.

The State Board of Health received from you an application dated Dec. 28, 1893, accompanied by a report of your engineer, Mr. Percy M. Blake, relative to a proposed water supply for the

town, to be taken from Dow's Brook within said town. The report of your engineer also contained the results of his investigations of other possible sources of supply in the town.

The Board has already considered plans for a water supply to be taken from Dow's Brook, submitted by a water committee of your town on Nov. 30, 1889; but the plans then submitted included a storage reservoir having somewhat less depth and smaller capacity than the one now proposed.

The water of Dow's Brook is of good quality. The reservoir in which it is to be stored is on the whole somewhat shallow, and in order to render the water less liable to deteriorate by storage and become affected by the disagreeable tastes and odors to which stored waters are sometimes subject, it should be thoroughly cleaned by the removal of all vegetable matter from its bottom and sides. Care should also be taken to prevent any pollution of the water by the farmhouses upon the water-shed.

The quantity of water which this source by itself will furnish with the storage now proposed, provided the dam is made water-tight, will be sufficient to meet the requirements of the town after water has been thoroughly introduced until there has been some increase in the population; and it is stated by your engineer that Bull Brook, also known as Egypt River, at a point not more than seven hundred feet from the site of the proposed dam, flows at a higher elevation than the water will stand in the proposed reservoir, so that additional water can be diverted into it from this brook when necessary.

The water of Bull Brook comes from a swampy region, and would not be of satisfactory quality for a public water supply if it was furnished directly to the consumers; but it is not a polluted water, or one that need be regarded as injurious to the health of those drinking it; and if a small proportion of it should be turned into the proposed storage reservoir in dry years, when there might otherwise be a shortage of water, the mingled waters when supplied to the town would not be of objectionable quality.

The Board concludes that the present plan for taking a water supply from Dow's Brook, supplemented by Bull Brook when necessary, is the best plan which has yet been submitted to it for the water supply of the town of Ipswich, and it believes this plan to be a suitable one for adoption by the town.

Longmeadow. The water board of Longmeadow applied to the Board Oct. 12, 1894, for its advice relative to taking the water of Cooley Brook in that town as a source of water supply. The Board replied as follows: —

Nov. 21, 1894.

The State Board of Health has considered your application dated Oct. 12, 1894, with regard to a proposed water supply for the town of Longmeadow, to be taken from Cooley Brook at a point above any source of pollution. Your application contains the following statements: —

"For several months past frequent measurements of the flow of the stream have been made, and the results show a flow of 8,750 gallons per hour, or 210,000 gallons per day. It is proposed to construct a receiving reservoir of either masonry or selected timber, which will contain 100,000 gallons. The stand-pipe will hold 110,000 gallons."

The Board has caused an examination of the water-shed of Cooley Brook to be made, also an analysis of a sample of water collected from the brook near the proposed point of taking, and finds that the water at the present time is of satisfactory quality for all the purposes of a public water supply.

It is better that the receiving reservoir should be constructed of masonry rather than of wood, because experience in other places has shown that wood in similar situations produces conditions which are favorable to the growth of organisms, and a consequent deterioration in the quality of the water stored in contact with it. It is desirable that the reservoir should be covered in such a way as to exclude the light.

The measurements of the flow of the brook, made by you during the past season, taken in connection with the area of the water-shed apparently tributary to it, as observed by one of the engineers of the Board, indicate that water sufficient for at least twice the present population of the town can be obtained from this source.

MILFORD. An application was received from the Milford Water Company April 20, 1894, for the advice of the Board relative to increasing its water supply by taking the water of a small pond situated near the present pumping station of the company. The Board replied as follows: —

May 3, 1894.

The State Board of Health has considered your application dated April 20, 1894, with regard to a proposed additional water supply to be taken from a small pond near the pumping station, from which water can be brought to the pumping station by gravity, and also for general advice as to the best plan of increasing the supply.

An examination of the small pond referred to has been made by

an engineer of the Board, and a sample of water from it has been analyzed. The pond has a very small water-shed, and would furnish so small a quantity of water daily that the supply from it would scarcely be appreciable. Moreover, the supply taken from the pond would not be wholly additional, because a part or the whole of the water which it would furnish now finds its way into the wells by filtration through the ground. It has been suggested by those connected with the works, that, as a pipe leading from this pond would supply water by gravity to the pumps, such a connection might have a special value in case of accident to the suction pipe or other similar emergency; but this is a point which can be determined better by you than by this Board. The quality of the water of the pond is such that it might be used for water supply purposes, though it is not nearly as good as the ground water obtained from your wells.

With regard to the second request, for general advice as to the best plan of increasing the supply, the Board advises that you make investigations with reference to increasing the supply of water to your wells by filtering the river water intermittently through the gravelly upland in their vicinity, in the same general manner that sewage is now filtered at Framingham. If the water should be applied evenly and intermittently to porous land having its surface six feet or more above the level of the ground water, in comparatively small quantities (say not exceeding 300,000 gallons per acre per day), it would be feasible to purify it so that it would be nearly, if not quite, as good as the water you now obtain from the wells when no water is admitted from the river. It seems probable that land suitable for this purpose may be found either west of the wells, between the railroad and the small pond concerning which you have asked advice, or north of the wells, between the railroad and the river.

Should you make these investigations and have additional information to present, the Board will advise you further in this matter.

MILTON. The Milton Water Company applied to the Board April 23, 1894, for its advice relative to taking water for a public water supply from the ground in the vicinity of Pine Tree Brook at a point east of Harland Street; this source to be supplemented by water taken from this brook near Harland Street in that town. The Board replied as follows: —

JUNE 8, 1894.

The State Board of Health has considered your application dated April 23, 1894, with regard to a new water supply for the town of Milton, to be taken from the valley of Pine Tree Brook within the

limits of the town, above Canton Avenue. As a part of your application you make the following statement: —

"It is proposed to obtain a supply of ground water from the meadow land on the east side of Harland Street, through which land the Pine Tree Brook flows; such ground water to be supplemented by water taken from the brook at a point near and just above the old dam sites on Harland Street. The brook water may be accumulated in a small settling basin and conducted thence by gravity to the pumping station of the company. If necessary, sand filtration of the brook water can be adopted. The water-shed above the point of taking is not less than four square miles, and includes a portion of the domain taken for metropolitan park purposes."

The application was also accompanied by the report and plan made by your engineer, showing the tests which had been made to determine whether a supply of ground water could be obtained, and the general method of obtaining the supply.

The Board has caused a careful examination to be made by one of its engineers of the locality and of the plan and report submitted, and has caused analyses to be made of water from Pine Tree Brook and from test wells near the point where it is proposed to locate the permanent well. The analyses and an examination of the surroundings show that water of excellent quality can be obtained from the ground at the site of the proposed well. The quantity of water to be obtained from an underground source is, necessarily, somewhat indeterminate; but it is probable that a well or wells at the proposed location will supply as much water as will be required for the town for a few years, and, possibly, a much larger quantity.

The quality of the brook water is such, in its natural state, that it would not be wholly satisfactory for a public water supply; and, in view of the danger of pollution by the present population and the population which is likely to locate upon a water-shed so near Boston, the Board is of opinion that the water ought not to be taken directly from this brook. It may be feasible to increase the quantity of water supplied by the well or wells by turning some of the brook water intermittently and in comparatively small quantities upon the ground at a considerable distance from the wells, but in such locations that it will filter through the ground into the wells. With this method of filtration properly conducted, it is probable that the brook water might be purified to such an extent that it would be of satisfactory quality until there is a considerable addition to the population upon the water-shed.

In order to prevent the pollution of the ground water, no sewage or other polluting waste should be turned into or upon the

ground in the vicinity of the well; and if there should be any large increase in population upon any part of the territory which contributes to the supply of the well, it would be necessary, in order to prevent the deterioration of the water, to provide a system of sewerage for conveying away the polluting wastes.

The Board calls your attention to the fact that it is now making investigations with a view to obtaining a water supply for Boston and its suburbs within ten miles of the State House, and that it expects to make its report to the Legislature at the beginning of next year. It will obviously require a few years, after the question is favorably acted upon by the Legislature, before the metropolitan supply will be available; and, even if Milton should desire to co-operate with other cities and towns in the metropolitan district in obtaining this supply, it may still be necessary to provide at least a temporary independent supply, in order to prevent a deficiency in the next few years.

If the proposed ground-water supply for Milton should prove deficient in quantity, or if the population should increase to such an extent as to make the water unsuitable in quality, it is very doubtful if it would be practicable to obtain from any other source a suitable independent supply for the town.

The Board, therefore, advises that the first works for obtaining a new supply should be built with reference to taking a supply from the ground only. It can be determined much better in the future, after the capacity of the ground has been tested by actual trial and after the report has been made upon the metropolitan water supply, whether or not it is desirable to attempt to obtain a permanent supply for the whole town from the proposed source.

MONSON. The committee on water supply of Monson applied to the Board March 8, 1894, for its advice relative to taking a public water supply from the water-shed of Conant Brook in that town. The Board replied as follows: —

MARCH 30, 1894.

The State Board of Health has considered your application with regard to a proposed water supply for the town of Monson. It is understood that you intend to take the supply from some point within the water-shed of Conant Brook, and that it will probably be taken from a large collecting well situated near a branch of Conant Brook known as Ingalls Brook.

The Board has caused this territory to be examined by one of its engineers, and has made analyses of samples of water from Conant Brook just below Ingalls Brook, from the two principal

branches of Ingalls Brook and from a test well near this brook. These analyses show that the water from all of these brooks is very soft, and of very good quality for a surface water, and that the water would be suitable for all the purposes of public water supply. The surface water, however, is not nearly as good as the sample from the test well, which is practically a spring water of excellent quality, and is also very soft.

There is no doubt whatever but that a sufficient quantity of water for the supply of the town can be obtained from this water-shed; and the results obtained from test wells, taken in connection with the results of an examination of the surrounding territory, make it probable that a sufficient supply can be obtained from the ground in this vicinity to warrant the adoption of the proposed plan for taking water from the ground. If this supply should prove insufficient, it will be possible at any time to supplement it by taking water from the brooks.

The Board would therefore advise that the Conant Brook water-shed is a suitable source from which to obtain a supply of water for the town, and would also advise taking the water from the ground, as is now proposed.

New Bedford. The water board of New Bedford applied to the State Board of Health Jan. 12, 1894, for its advice relative to the propriety of taking an additional water supply from the great ponds in the town of Lakeville, to which the Board replied as follows: —

Feb. 21, 1894.

The State Board of Health received from you on Jan. 12, 1894, an application asking its advice with regard to a proposed additional water supply from the Lakeville ponds, said application being accompanied by the report of Messrs. Rice & Evans, hydraulic engineers, indicating the proposed methods of taking the water, and by a copy of the draft of an act accompanying the petition of your board to the Legislature for authority to increase the water supply of New Bedford.

The plan proposed, as indicated by these various documents, is to take water from Little Quittacas Pond, and to keep this pond supplied with water from the other Lakeville ponds by providing more ample water ways between Great Quittacas and Little Quittacas ponds, and between Pocksha and Great Quittacas ponds. It is further proposed by the act that this water supply shall be taken from a reserve to be created by a dam at the outlet of Assawompsett Pond, or by a dam or dams at the outlet of Long Pond.

The Board finds that the present consumption of water in New Bedford has reached the limit of capacity of the present sources of water supply in very dry years, and an additional supply is now required. With regard to the source that this supply should be taken from, there seems to be no question but that it should be taken from one or more of the Lakeville ponds. These ponds are very large and are fed from a large water-shed, so that there is no doubt that they can be made to furnish a sufficient quantity of water for a very long time in the future for all of the communities within a reasonable distance of them which they would naturally be expected to serve. The question with regard to the source of an additional water supply, therefore, narrows to the relative quality of water in the different ponds and the best method of obtaining the required quantity of water, having due regard to the quality and to the effect which the method of taking the water may have upon the various interests to be affected thereby.

Little Quittacas Pond, one of the present sources of supply, contains the best water of any of the ponds under consideration, and although the other ponds will furnish a water that might be used for all the purposes of a public water supply, there is considerable difference in the quality of the water in them, and the water of all of them would be improved by passing through and mingling with the water of Little Quittacas Pond before being conveyed to the city.

The different ponds rank as follows in regard to the quality of their waters: Assawompsett Pond, Great Quittacas Pond, Long Pond.

No examinations have been made of the water of Pocksha Pond, as it has been regarded as a part of Assawompsett Pond.

It will be seen that Assawompsett Pond contains the best water for supplementing the supply from Little Quittacas Pond; but the distance between these ponds is so great that the extra cost of taking water from Assawompsett Pond would not be warranted when a water as good as that in Great Quittacas Pond is close at hand. Of the two nearer sources, Great Quittacas Pond will furnish a much better water than Long Pond, and it has the further advantage that it can easily be connected with Little Quittacas at a point across the pond from the proposed pumping station, so that its water will have a better opportunity to be improved in its passage through Little Quittacas Pond, both by mingling with the water of this pond and by bleaching.

Under the provisions of the act which you have submitted it is proposed to obtain the required quantity of water from a reserve to be created by a dam at the outlet of Assawompsett Pond, or by

a dam or dams at the outlet of Long Pond. Inquiry had been made of your superintendent for information bearing upon the question of the amount of water which such a reserve as is contemplated can supply; and, while he has furnished all the information which he has been able to obtain, it is insufficient as a basis for estimating at all definitely the amount of water to be obtained in this way. Further inquiry has been made in other directions by the engineers of the Board, and the quantity of water which such a reserve as is contemplated will supply has been carefully computed upon the basis of the information obtained, which, although meagre, is the best that is now available. The result of these computations has led the Board to the provisional conclusion that it will not be feasible to obtain in dry years a sufficient water supply for the cities of Taunton and New Bedford for a reasonable time in the future from the contemplated reserve.

The question of creating a reserve by raising one or all of the ponds should also be considered with reference to its effect upon the quality of the water. If all of the ponds should be raised sufficiently to overflow the very extensive swamps and cranberry bogs bordering upon them, it would materially injure the quality of the water in the ponds for water supply purposes.

If the storage should be confined to Long Pond alone, and the quality of the water should deteriorate owing to the flowage of swamps and other lands, the quality of the water supplied to New Bedford would not be appreciably affected, because very little if any of the water of Long Pond would ever find its way through Assawompsett and Great Quittacas into Little Quittacas Pond; but any deterioration of the water of Long Pond would have an unfavorable effect upon the Taunton water supply, a portion of which is to be taken from Assawompsett Pond, not very far from where the water of Long Pond enters it.

A reserve such as is contemplated, if found to be feasible, would prevent or diminish the injury to water powers dependent wholly or in part upon the water which flows from these ponds; but it may be questioned whether the injury to the property surrounding the ponds by raising their level would not more than offset the damage that would result to the water powers by taking the water without creating a reserve.

With the information now available, the Board does not think it advisable that you should obtain an act which will limit your taking of the water of these ponds to a reserve such as is contemplated, or which will make compulsory the erection of a dam to store a reserve of water equal to one year's supply for the cities of Taunton and New Bedford.

If the supply is not to be taken from a reserve, the question arises as to how it shall be taken. The plan proposed by your engineers and referred to by you provides for more ample water ways between the ponds, by which all of the chain of ponds extending from Assawompsett to Little Quittacas can be put in free communication with one another. If these water ways should be kept open, the draft upon Little Quittacas for supplying New Bedford with water would cause all of the ponds to lower in summer more than they otherwise would, and consequently the flow out of Assawompsett Pond into the Nemasket River would be diminished.

Another plan for taking water, which would cause less diminution in the summer flow of the Nemasket River, is to supplement Little Quittacas by turning into it water from Great Quittacas Pond only, obtaining the required quantity of water in summer by lowering the level of the pond. Estimates show that if this pond can be drawn down about six feet it will supply in the driest year, in connection with the sources now used, enough water to supply the city of New Bedford until its population reaches 100,000. A somewhat larger supply might be obtained almost wholly from this source if provision should be made for turning water from Pocksha Pond into Great Quittacas in the months of March and April, provided Great Quittacas should not then be full.

It is not probable that there would be much difference in the quality of the water obtained by either of the two plans just mentioned, although the conditions are somewhat more favorable in the first one. The Board cannot advise definitely as to which of these two plans will be the better one to adopt, having due regard for the future; because it is not fully informed as to whether it is feasible to draw Great Quittacas Pond down to the extent above indicated, or, if it can be done, whether any local interests will be seriously affected thereby. It is obvious, however, that this pond will furnish all of the water required for New Bedford for quite a long time in the future without very much lowering of its surface, even in the dry portion of the year; and it may be that the right to take the waters of this pond is all that is desirable at the present time.

The water now supplied to the city is drawn directly through a conduit from the Acushnet reservoir, and, although the quality of the water is not such that it would be regarded as detrimental to the health of the citizens of New Bedford, it is, nevertheless, on account of its contact with the swamps upon the water-shed and its storage in a shallow reservoir, a much poorer water than that in the Lakeville Ponds. It is, therefore, very desirable that pro-

vision should be made for conveying the water of the ponds to New Bedford in such a way that it will not be necessary to mingle it with the water of this reservoir.

NEWBURYPORT. The mayor of Newburyport applied to the Board Dec. 21, 1893, for its opinion as to the probable efficiency of a filter constructed by the Newburyport Water Company near its pumping station in supplying a "safe water for use in the public schools and generally throughout the city." To this application the Board replied as follows: —

FEB. 17, 1894.

The Board has caused an examination to be made, by one of its engineers, of the filter constructed by the Newburyport Water Company near its pumping station.

The medium through which it is intended to filter the water is a layer of Plum Island sand about three feet in thickness, which would not in itself prevent the passage of disease germs. It is understood, however, that a coagulant is to be added to the water before filtration, as is the usual practice with the so-called mechanical filters, so as to render the filtration more effective.

The Board has not had any opportunity to test the filter at Newburyport, as it is not yet in operation, but has made examinations of the water from several mechanical filters, and, judging from the results obtained, is of opinion that a filter like that at Newburyport cannot be depended upon to remove the disease germs from the Merrimack River water so as to render it safe for drinking in the public schools or by the citizens of Newburyport.

NEWBURYPORT WATER COMPANY. An application was received from the Newburyport Water Company June 20, 1894, for the advice of the Board relative to taking an additional water supply from wells upon the banks of the Artichoke River in Newburyport. The Board replied as follows: —

JULY 27, 1894.

The locality near the river to which the attention of the Board has been particularly called is just north of the old Newbury road, where five tubular test wells have been driven. Samples of water have been collected from these wells and analyzed, and the analyses show that the water contains so much iron that it would not be suitable for laundry and some other purposes.

Judging from the information furnished as to the results obtained

by means of the test wells, and from an examination of the wells and of the surrounding territory, it does not seem probable that enough water could be obtained from this source to furnish an adequate additional supply for the city.

The Board therefore concludes that, owing both to the inferior quality and insufficient quantity of water which this source will furnish, it is not a suitable one from which to take an additional supply for the city of Newburyport.

NORTH ATTLEBOROUGH. An application was received from the water commissioners of North Attleborough Oct. 10, 1894, for the advice of the Board relative to a proposed additional water supply for the town, the sources proposed being the head-waters of Ten-mile River, and driven wells to be located near the present pumping station. The Board replied as follows: —

DEC. 20, 1894.

The sources referred to are, first, the head waters of Ten-mile River in the southerly part of the town of Wrentham, at a point just above the Walpole and Wrentham branch of the New York, New Haven & Hartford Railroad; and, second, a supplementary supply of ground water to be obtained by driven wells in the present pumping station lot.

In the report of your engineer are given the results of tests made by driving wells in the vicinity of the present pumping station, and measurements of the volume of water flowing in the Ten-mile River at various points above the pumping station. His report also indicates how a supply of water may be furnished to the inhabitants of the village of Plainville in the town of Wrentham, from the works of the town of North Attleborough.

The State Board of Health has caused an examination to be made, by one of its engineers, of the water-shed of the Ten-mile River, near and above the present pumping station, and of the material taken from your test wells near the pumping station at various depths below the surface of the ground. It has also caused analyses to be made of samples of water collected by your engineer from some of the test wells, and from the Ten-mile River above the point from which it is proposed to take an additional water supply.

These analyses show that the water taken from some of the test wells contains sufficient iron to make the water unsuitable for laundry and some other purposes, while the water from others is of good quality, and similar in character to that obtained from the well from which the supply of the town is now taken.

The analyses of samples taken from the river show that the water is naturally of excellent quality for a surface water; but in the case of water taken from a running stream an analysis cannot show that the water is safe for drinking. This depends upon the absence of infectious matter such as might get into a stream if any sewage whatever were turned into it. The examination of the territory above the proposed point of taking water from the river indicated that no sewage now enters this stream; and it is essential, if water is taken directly from the river without filtration or storage in a large reservoir, that this freedom from pollution should continue in the future.

The gaugings of the flow of the Ten-mile River near the point at which it is proposed to take the water, taken in connection with the size of the water-shed above this point, indicate that a sufficient quantity of water can be obtained from the river to warrant the construction of works for supplying water to the town of North Attleborough, or jointly to the town of North Attleborough and the village of Plainville.

It is probable that a limited additional supply of water of satisfactory quality can be obtained from the ground in the vicinity of the present well by some suitable extension of the collecting works, taking care that they do not extend into the territory which furnishes the water containing an excess of iron.

The Board, therefore, advises that the Ten-mile River at the point above indicated is a suitable source from which to obtain the next addition to the water supply of the town of North Attleborough.

NORTON. An application was received Dec. 6, 1894, from A. H. Sweet and other petitioners of the town of Norton for the advice of the Board relative to the propriety of taking a public water supply from certain sources within the town, or from the works of the adjoining towns of Attleborough or Mansfield. The Board replied as follows: —

JAN. 3, 1895.

The State Board of Health received from you a communication dated Dec. 3, 1894, in which you state that you represent certain petitioners to the Legislature, who respectfully request that a fire district, to be established in the town of Norton, be authorized to provide a water supply for itself and the inhabitants of said town for the extinguishment of fires and for domestic and other purposes; and they further request that the fire district may be empowered to take any source of water supply within the town of

Norton, or to obtain a supply from the town of Attleborough. In your communication you also refer to the possibility of obtaining a supply of water from the present works of the Mansfield water supply district.

Of the possible sources within the limits of the town, you mention driven wells near the factory of A. H. Sweet, wells or filter galleries near the Wading River, just above the main road from Norton Center to Attleborough, and wells or a filter gallery near the mill pond of G. H. Talbot. You also refer to the possibility of taking water directly from the Wading River at the point before indicated, and state that under any of these plans it is probable that a connection would be made with pumps located at G. H. Talbot's mill for taking a fire supply directly from his mill pond.

Tests of the ground have been made at only one of the ground water sources mentioned, namely, that near the factory of A. H. Sweet. At this place two wells were driven, under the direction of your engineer, and samples of water collected from them by him have been analyzed by this Board, and the water was found to contain so large a quantity of iron that it would be unsuitable for laundry purposes, and in other respects an unsatisfactory water for the purposes of a public water supply.

With regard to the other ground-water sources, which in the absence of tests by driven wells could only be examined superficially, it may be stated that the conditions appeared to be more favorable for obtaining such a supply near the Wading River than near Talbot's mill pond.

Samples of water from the Wading River at the point before indicated and from Talbot's mill pond on the Rumford River have been analyzed, and the analyses of the two waters differ but little. Both have the brownish color which water acquires from contact with vegetable matter in swamps or very shallow ponds. The Wading River has a comparatively small population upon its watershed, while the Rumford River receives the drainage of the town of Mansfield and a large part of the town of Foxborough. Neither of these streams would furnish a wholly satisfactory water supply if the water were taken directly from them; and the Board therefore advises you to make further investigations, with a view to obtaining a satisfactory ground-water supply, unless you can arrange to obtain water from the present works of either Attleborough or Mansfield. The Board has made many analyses of the water now supplied to these places, and in both cases the water is of excellent quality, and the quantity is probably sufficient to enable these places to supply the inhabitants of Norton for many years.

The Board will advise you further, if so requested, with regard

to the sources from which the Norton fire district may obtain an independent supply, when you or the district have more definite information to present with regard to the possible sources.

QUINCY. An application was received Nov. 3, 1894, from the city of Quincy, for the advice of the Board relative to a proposed increase of the water supply of the city by the construction of a new storage reservoir and the diversion of the water of Blue Hill River. The Board replied as follows: —

JAN. 3, 1895.

The State Board of Health received from you on Nov. 3, 1894, an application for its advice with regard to a proposed additional water supply for the city of Quincy. This application was accompanied by a plan and report, outlining a proposed scheme for increasing the quantity of water supplied to the city by the construction of a new storage reservoir near the existing one, and by diverting into the existing and proposed reservoirs the waters of the Blue Hill River.

The plan and report also provide for protecting and improving the quality of the present water supply by taking land adjacent to the brook which feeds the reservoir, thereby making it possible for the city to abolish piggeries, and to drain the swamps and meadows so that they will not impart color and taste to the water. In connection with the new reservoir it is proposed to lay a second main pipe to the existing pumping station.

The plans submitted are in the nature of outlines, which give the capacity of the proposed storage reservoir and the area of the water-shed feeding it, but do not give estimates of cost, nor tests of the ground where the dam of the proposed reservoir is to be built, to serve as a basis for determining the feasibility of constructing a tight and safe dam at this place.

With a view to ascertaining whether an additional supply is needed at the present time, the capacity of the present sources in a very dry year, such as should be used in estimating the safe capacity of a water supply, was estimated, as well as the probable consumption of water for the next few years; and it was found that the consumption in 1895 would be likely to exceed the capacity of the present works in a very dry year. As the population of Quincy is increasing rapidly and the consumption of water still more rapidly, there is no question that a further supply for the city should be provided at once; but a further study was required, in order to decide whether the works for furnishing this supply should be of a permanent or temporary character.

As you are aware, the State Board of Health has been making investigations, for the past year and a half, for an additional water supply for the city of Boston and the suburban cities and towns within ten miles of the State House, and is to report the results of its investigations to the Legislature of 1895. The city of Quincy may, therefore, consider the question of obtaining its future water supply either from independent works to be constructed by the city or from the larger works to be provided for the supply of the metropolitan district; and a decision as to whether the works to be built now for increasing the water supply of Quincy ought to be of a permanent or temporary nature, may depend upon whether it is for the interests of the city to obtain its water supply independently, or in connection with the other cities and towns in the metropolitan district.

In order to determine this point as well as it is practicable to do so without more definite information than is now available, a plan was outlined for utilizing as fully as possible the present water-shed, the water-shed of the Blue Hill River and the small water-shed tributary to the proposed reservoir, and the quantity of water to be obtained by this plan and the approximate cost of works were estimated.

It was found that by the construction of the proposed reservoir and the diversion into it and the existing reservoir of the waters of the Blue Hill River at a point below the outlet from Great Pond, the supply would be so increased as to meet, in the driest year, the requirements of the city until 1905. To prevent a deficiency after that year it would be necessary to construct a large reservoir toward the upper end of Blue Hill River, by building a dam across it not far above where the river is crossed by the Taunton turnpike.

With regard to this reservoir, Percy N. Blake, C.E., reported in 1890 that it would cover an area of 400 acres, and have a capacity of 1,400,000,000 gallons. By its addition the supply would be largely increased, so that it is estimated that it would meet the requirements of the city until 1921.

The construction of this reservoir would develop these sources to the highest practicable limit, and in order to obtain any further supply a new source must be found. It may be added that a general survey of the sources within a reasonable distance of Quincy did not disclose any, not now used for water supply purposes by some other city or town, which would furnish any large quantity of good water.

The quality of the water of the Blue Hill River is not very different from that furnished by the present sources; but the water of both sources could be greatly improved by the drainage of the

swamps and the removal of the soil and vegetable matter from the bottom and sides of the storage reservoirs.

The sources which the State Board of Health now has in view for the water supply of the metropolitan district will furnish a large quantity of water, and can be supplemented from time to time at a reasonable cost by the addition of other sources, so that the supply will be ample for a very long time in the future. The quality of the water of the proposed sources, as it now flows in the streams, is very good; and it is proposed to improve it by the drainage of swamps and the construction of very large, well-cleaned reservoirs, so that it will be better than any water which Quincy can obtain from independent works, even if Quincy should improve the quality of its water by the methods already indicated.

There still remains to be considered the relative cost of these two methods of obtaining a water supply; in the case of the metropolitan system the total cost is quite well known, although the method of apportioning the cost to the different cities and towns is not. In the case of the independent system of works no estimates of cost have been furnished by you, and the engineers of this Board have had to make the best estimates that they could, under the circumstances, of the various items of work required for the full development of this system. If it is assumed for the present purpose that the cost of the metropolitan supply will be divided in direct proportion to the number of inhabitants in the various cities and towns, it is found that the yearly cost to Quincy for obtaining its water from the metropolitan supply will not be more than two-thirds as much as for obtaining it from independent works.

The opinion of the Board, therefore, based upon the information which is now available, is that it is decidedly for the interests of the city of Quincy to become a part of the metropolitan water supply district, rather than to attempt to obtain a permanent supply by independent action; and the Board advises that you should proceed to obtain a supply of water for the next few years by means of works of a temporary character, rather than to build expensive permanent works, which will have little value in the future if you should obtain your supply from the metropolitan system.

Two plans for temporarily increasing the supply are suggested: —

The first proposes the utilization of the water which filters from the existing reservoir and is wasted, and the water which flows down the small brook upon which the proposed reservoir is located. These waters could be diverted into a small open basin, to be dug some distance below the dam, and pumped from this basin back into the reservoir, from the time in the early summer when the

reservoir stops overflowing until the season is so far advanced that it becomes evident that there will be no shortage of water during the year. This plan of pumping back into the reservoir, rather than directly into the pipe leading to the existing pumping station, is suggested because the water filtering past the dam of the reservoir contains so much iron that it would be objectionable if pumped directly to the city, and this iron would disappear by sedimentation if the water were pumped back into the reservoir at a point not too near the gate house.

The second plan proposes supplementing the present supply by taking water from the Blue Hill River, either by diverting the water by gravity through an open channel or by a pipe, — as proposed in the permanent plan for taking water from this river, — or by the erection of a temporary pumping station at the point where the river approaches nearest to the existing reservoir.

For such temporary works for taking water as are here proposed it will probably be cheaper to lease land than to buy it, and to arrange with the mill owners upon the river for the temporary diversion of the water rather than to make a permanent taking.

Of the two plans proposed, the first would be the cheaper one, and would probably supply sufficient water to prevent a shortage in a moderately dry year for the next three years, but might fail if an extremely dry year should occur within that time. The second plan has the advantage that it would furnish a more abundant and certain supply. If the first plan were adopted, and it should be found inadequate, it might still be feasible to resort to the second.

Other methods of obtaining a temporary additional supply may suggest themselves to you, such as, for instance, the purchase of water from the town of Braintree, if it should decide to increase its supply by taking water from Great Pond.

SWAMPSCOTT. The Marblehead Water Company, supplying water to the towns of Swampscott and Nahant, applied to the Board July 9, 1894, requesting the Board to give its opinion upon the desirability of taking the water of Floating Bridge Pond in Lynn as a source of public water supply. The Board replied as follows: —

AUG. 3, 1894.

In compliance with your request, dated July 9, 1894, that the State Board of Health should examine the water of Floating Bridge Pond, also known as Glenmere Lake, in the city of Lynn, with reference to its use for domestic purposes, the Board has caused the water to be examined chemically and microscopically, and has

had the pond and its surroundings examined by one of its engineers.

As a result of these examinations, the Board is of the opinion that the water of this pond is not of suitable quality for domestic use. The principal objection to the water at the present time is that it contains a very large number of microscopic organisms, which give the water a greenish turbidity and a disagreeable odor and make it unpalatable. The pond is also exposed to pollution at the present time from the population in its immediate vicinity, and this population is likely to increase rapidly in the future, owing to the proximity of the pond to the thickly settled portions of the city of Lynn.

Copies of the chemical and microscopical analyses are enclosed herewith.

WAREHAM, ONSET WATER COMPANY. An application was received May 17, 1894, from the Onset Water Company, for the advice of the Board relative to taking a water supply from Jonathan's Pond as a supply for Onset, a summer resort in Wareham. The Board replied as follows: —

JUNE 9, 1894.

The Board has caused an examination of this pond and an analysis of its water to be made, and finds that the water is very soft, and of excellent quality for all the purposes of a public water supply.

The limits of the territory which contributes to the supply of the pond, either by direct flow over the surface or by filtration under ground through the sandy territory in which the pond is situated, are not well defined; and it is not, therefore, practicable to determine at all definitely the quantity of water which this source will furnish. It seems probable, however, that it will furnish the water required for the portion of the town of Wareham which the company is authorized to supply from it.

WATERTOWN. The Watertown Water Supply Company applied to the Board April 19, 1893, for its advice relative to certain proposed plans for filtering the public water supply of the town. To this application the Board replied as follows: —

FEB. 3, 1894.

The State Board of Health received from you on April 20, 1893, an application asking its advice with regard to certain proposed plans for filtering water, to be used in connection with your works for supplying water to the towns of Watertown and Belmont. This application received the attention of the experts of the Board

soon after it was submitted, but owing to the fact that you were making investigations with regard to a further supply during nearly the whole of the summer, and the time required to determine the probable effect of filtration upon the water which you found as a result of these investigations, the Board has not been prepared to reply until the present time.

You have found by your examinations a location where you can pump water from the ground near the Charles River to supplement the supply obtained from your filter gallery. This water has been examined by the Board, and, while it contains iron and manganese, and does not show the high degree of chemical purification which water attains when it filters a sufficient distance through the ground under favorable circumstances, it is nevertheless very nearly free from bacteria, while the river water contains a very large number, thus showing that the water is rendered very nearly pure, bacterially, by its filtration through the ground.

Upon further examination it was found that the color was due to the presence of organic matter which held the iron in solution, and would not permit it to be removed by aeration and subsequent sedimentation, or by rapid filtration without the use of some chemical. Upon treating the water with aluminum hydrate or aluminum sulphate, it was found that the color, and with it nearly all of the iron and some of the manganese, could be removed, either by precipitation, if the water was allowed to stand long enough, or by filtration.

Some samples of this water were also collected by Professor Carmichael on Nov. 17, 1893, who, after treating it with crude aluminum sulphate, filtered it through an experimental filter, constructed so as to imitate as nearly as practicable upon a small scale the Warren filter, and sent the filtrate to the chemist of this Board. Our chemist did not have a sample of water collected from the wells at the same time that the sample was collected for filtration; but, by making a comparison between the filtrate and the unfiltered water collected from the wells nearly a month earlier, it was found that the addition of the aluminum sulphate and subsequent filtration had removed nearly all the color, iron and alumina originally in the water, and about one-third of the manganese, leaving .1656 of a part of oxide of manganese per 100,000, or .1 grain per gallon; and that it had added to the water rather more than one and one-half parts per 100,000 of sulphuric acid. This sulphuric acid is not a desirable addition, and, in combination with the lime originally in the water, would make the water to this extent more objectionable for use in boilers, but the treatment would make the water appear better to water consumers. The amount of aluminum sulphate used in the experimental filtration is said to have been two and one-half grains per gallon.

The advantages of the proposed filtration do not appear to the Board to offset the possible risks to the health of the community by the use of a large and indefinite amount of alum.

Westborough Lunatic Hospital. The superintendent of the Westborough Lunatic Hospital applied to the Board Feb. 23, 1894, asking "whether, in the opinion of the Board, the water of Chauncy Pond would be suitable for drinking and domestic purposes if filtered." The Board replied as follows: —

March 30, 1894.

The State Board of Health has considered your request as to whether the water of Chauncy Pond would be suitable for drinking and domestic use if filtered, and would state that it is a somewhat difficult matter to filter a water of this character in such a manner as to render it both wholesome and palatable; and the Board therefore would not advise the adoption of this method of obtaining a water supply until an examination made by some competent engineer had shown that it was not feasible to obtain a more satisfactory supply in some other way.

Should you wish to proceed further in the investigations for a water supply, the Board will give you such assistance as it can in the matter.

Westport, Horse Neck Beach. An application was received Jan. 15, 1894, from Mr. Thomas B. Tripp of New Bedford, for the advice of the Board relative to introducing a water supply at Horse Neck Beach (a summer resort in Westport). The Board replied to this application as follows: —

May 3, 1894.

The State Board of Health received from you on Jan. 15, 1894, an application for its advice with regard to a water supply for that portion of Westport known as Horse Neck Beach, and on April 23 it received from you and had analyzed samples of water from a six-inch tubular well sunk in the bottom of an old well on the side of a hill, located northerly from the beach, and from one of several small springs at the foot of the hill.

The analysis shows the water supplying the tubular well to have been at some time polluted, probably by drainage from a farmhouse above the well, and again purified to a considerable extent by its passage through the ground to the well. The analysis of water from the spring shows only slight traces of previous pollution, and it is a much purer and softer water than that taken from the well,

notwithstanding the fact that the sample contained some foreign matter, owing to the disturbance of the bottom caused by taking the sample. If the well is to be used as a source of supply, provision should be made for diverting the drainage from the farmhouse to a point where it cannot get into the well; and the water of the well should be analyzed from time to time, in order to determine if its character changes, and if it is of suitable quality for continued use as a drinking water.

It is not feasible to predict at all definitely the amount of water which these sources will furnish in dry seasons. A larger supply could probably be obtained from the springs, by excavating a basin of suitable size, than from the well; but both of these sources may be required in order to furnish a sufficient supply of water for the inhabitants of the beach, and it would be well to arrange the works so that the water could be taken from both sources. If a basin should be constructed at the site of the springs, it should be so arranged as to exclude all surface water and animal life, and should be covered to exclude the light.

WINCHENDON. An application was received Feb. 6, 1894, from the committee on water supply of the town of Winchendon, for the advice of the Board relative to taking the water of Upper Naukeag Pond as a public water supply for Winchendon. The Board replied as follows: —

FEB. 17, 1894.

The question of taking a water supply for Winchendon from Upper Naukeag Pond was brought to the attention of the Board in 1888 by an application from the selectmen, and the Board, in its reply to the selectmen, dated July 3, 1888, made the following statement with reference to this pond as a source of water supply: —

"The Upper Naukeag Pond will evidently furnish a sufficient quantity of water for Winchendon and Ashburnham for a long future. Its surroundings appear unusually favorable for insuring a very good quality of water, and chemical examinations show an unusually small amount of impurity; but a peculiar and disagreeable odor has been found with every sample tested, which grows more disagreeable the longer it is kept. A visit to the pond in June and an examination of samples from many parts of the pond show the odor to be in all parts of it. The cause of this odor has not been determined, but it has existed during the past four months, and is so marked that the Board does not, at present, recommend the adoption of this pond as the source of supply."

It will be observed that this reply was favorable in respect to the quantity of water to be obtained from this pond, and was unfavorable in regard to quality, only because the water of the pond had a peculiar and disagreeable odor for the four months that the water of the pond was examined before the reply was made. The odor disappeared in August, 1888, and was again noticed in a sample collected in April, 1889. Since 1889 samples have been taken every year, as follows: two in August, 1889; one in September, 1891; four from April to October, 1892; and three from March to August, 1893. In none of the samples taken since April, 1889, has there been any recurrence of the disagreeable odor noticed before that time; and as a rule there has been no odor whatever, even under the severe tests at the laboratory, where the odor is taken immediately after agitating water which has stood for some time in a closed gallon bottle. It may therefore be said that the later examinations of the water of Upper Naukeag Pond show that the odor noticed in the earlier samples does not recur either regularly or at frequent intervals.

The extended examinations by the Board of the water supplies of the State since 1887 have shown conditions at other places somewhat resembling those at Upper Naukeag Pond. The water supplies of Plymouth, Norwood and Hudson, which are all taken from natural ponds that usually furnish very good water, were affected in 1892 and 1893 by growths of minute organisms which gave the water an unpleasant taste and odor at about the same season of the year that the odor was so noticeable in Upper Naukeag Pond. Water was introduced into Plymouth in 1855, and into Norwood and Hudson in 1885. In Plymouth no serious trouble has occurred, except at very rare intervals. In Norwood and Hudson no serious trouble was experienced until the years above mentioned.

In view of the later experience with the Upper Naukeag Pond and the general experience with similar pond waters in other places in the State, the Board is of the opinion that Upper Naukeag Pond will furnish a water generally of excellent quality for all the purposes of a public water supply, subject, however, in common with many ponds in use for water supplies, to occasional seasons when the odor is disagreeable.

Another application was received March 23, 1894, from J. H. Fairbank, chairman of the water committee of the town of Winchendon, stating that the committee desired to investigate Naukeag Pond in Ashburnham and sources within the town of Winchendon, from which a water sup-

ply might be obtained from bored or driven wells, and requesting the advice of the Board as to what investigations should be made by the town with regard to finding a suitable supply in the town of Winchendon. The Board replied as follows: —

APRIL 6, 1894.

The State Board of Health received from you March 23, 1894, an application stating that you desire to investigate, as sources of supply for the town, Upper Naukeag Pond in the town of Ashburnham, and sources within the town of Winchendon from which a supply may be obtained from bored or driven wells, or by some other suitable means; and you also ask the advice of this Board as to what investigations you should make with regard to finding a suitable supply in the town of Winchendon. You make the further request that the reply be made as promptly as possible, so that it may be available for use during the present session of the Legislature.

The Board has already considered the question of a water supply for the town, in response to previous applications from the town authorities. On July 3, 1888, in response to an application relative to Upper Naukeag Pond in the town of Ashburnham as a source of water supply for Winchendon, the Board made a reply which contained the following statements: —

"The Upper Naukeag Pond will evidently supply a sufficient quantity of water for Winchendon and Ashburnham for a long future. Its surroundings appear unusually favorable for insuring a very good quality of water, and chemical examinations show an unusually small amount of impurity; but a peculiar and disagreeable odor has been found with every sample tested, which grows more disagreeable the longer it is kept. A visit to the pond in June, and an examination of samples from many parts of the pond, show the odor to be in all parts of it. The cause of this odor has not been determined, but it has existed during the past four months, and is so marked that the Board does not, at present, recommend the adoption of this pond as a source of supply; but does recommend that the town employ a competent engineer, skilled in this kind of work, to make the necessary investigations to determine if an abundant and unobjectionable supply cannot be obtained from underground sources nearer the town."

Since 1888 the Board has caused analyses to be made of the water of Upper Naukeag Pond from time to time, and on Feb. 17, 1894, in response to a second application, gave its views as to the quality of the water which Upper Naukeag Pond would furnish, the reply concluding with the following statement: —

"In view of the later experience with the Upper Naukeag Pond and the general experience with similar pond waters in other places in the State, the Board is of the opinion that the Upper Naukeag Pond will furnish a water generally of excellent quality for all the purposes of a public water supply, subject, however, in common with many ponds in use for water supplies, to occasional seasons when the odor is disagreeable."

With its present information, the Board believes Upper Naukeag Pond to be an appropriate source of water supply for the town of Winchendon, unless some equally good or better supply can be found nearer the town.

The Board has caused an examination to be made by one of the engineers of possible sources of supply nearer the town, and finds that there are three which it is desirable to investigate.

The first of these sources is one from which a ground water supply may possibly be obtained. It consists of low land bordering Miller's River, rather more than a mile from the town, and near the first crossing of the Cheshire division of the Fitchburg Railroad over the river.

It is in this location that two test wells were driven, and the results as reported are unfavorable, since the thickness of the water-bearing stratum of gravel in one case was only about six inches, and in the other eighteen inches. These wells are also said to have been driven to a depth of only eighteen feet in one case and twenty-four feet in the other. It would be useless to attempt to obtain a ground water supply at this place, unless further tests made by driving wells show that the porous material extends to a depth of twenty-five feet or more below the surface of the ground, and is much thicker than is indicated by the tests already made. It is also necessary that the porous material should extend over a considerable area, so that a well or wells at this place would draw water from a considerable distance, and there would be enough water stored in the interstices of the porous ground to prevent a deficiency during the drier portions of the year.

As a rule, the ground-water supplies of the State, when taken from unpolluted territory, have furnished better water than can be obtained from any surface source; but in a few cases the water has contained iron, which has rendered it less palatable and has been particularly objectionable for laundry use on account of the stain imparted to white clothes. While it seems probable that the water if obtained in sufficient quantity from this source would be of good quality, there is some uncertainty, and it would be necessary to determine by investigation the quality as well as the quantity of water to be obtained.

The second source is the ground near Miller's River, below the village of Hydeville. Judging from surface indications, the conditions are not as favorable for obtaining a ground-water supply at this place as from the first source, though it is possible that test wells may show more favorable conditions beneath the surface than are now anticipated; and it may, therefore, be desirable to make some tests by driving wells at this place.

In considering a water supply from this source, it is desirable also to have the territory below the town examined with reference to the purification of the sewage whenever a system of sewerage shall be adopted. If the land where the water supply would be taken is the only available land for sewage filtration, it is better that the water supply should be taken from some other source. If, however, there are other places where the sewage could be filtered, it will only be necessary to consider whether there will be an extra cost for conveying the sewage to the other land.

The third source is the so-called Stone Lot, supplemented by water from Beaman Brook at a point in Massachusetts near the Cheshire division of the Fitchburg Railroad. This plan would involve the construction of a storage reservoir upon the Stone Lot and a pumping station at Beaman Brook for pumping water into the reservoir. It is probable that a sufficient supply of water for the town could be obtained by this plan, provided a water-tight reservoir having the capacity stated in the report of the sub-committee on water supply in 1888, namely, 48,000,000 gallons, can be constructed upon the Stone Lot. There is no reason to doubt that the small portion of the supply which would come directly from the Stone Lot would be of good quality. The water of Beaman Brook has not yet been analyzed.

The tests suggested for ascertaining whether a sufficient supply of ground water can be obtained should be made under the direction of some engineer who has had experience in similar investigations. If the supply is taken from the ground, the distributing reservoir to which it is pumped should be covered to exclude the light, as the water would otherwise deteriorate.

The Board cannot advise more definitely with regard to the most appropriate source of supply for the town until it receives additional information from you.

Another communication was received from the water committee of Winchendon, dated May 11, 1894, relative to certain tests which had been made in the Prentice Meadow, so called, in Winchendon, with the object of obtaining a

water-supply for the town. To this application the Board replied as follows: —

AUG. 3, 1894.

The State Board of Health received from you a communication dated May 11, 1894, relative to certain examinations which had been made with a view to obtaining a supply of water from the ground bordering upon Miller's River at a place locally known as Prentice Meadow, near the first crossing above the town of the Cheshire division of the Fitchburg Railroad over the river. With this communication you forwarded a plan showing the location of driven test wells, samples of the material penetrated by them taken from different depths below the surface of the ground, and a statement of the depths of the various wells and of the amount of water which could be pumped from them with a hand pump. On June 26 you furnished similar information and samples relating to additional wells driven in the vicinity of the others.

In order to obtain further information with regard to this source, the locality has been visited by one of the engineers of the Board, and the question of a supply from this place has been carefully considered.

A sample of water collected and forwarded by you from one of the test wells in the meadow was analyzed, and was found to be of excellent quality. This is probably a sample of water percolating from the high land back of the meadow toward the river, while if a water supply were to be taken from the ground at this place the level would be lowered by pumping so that some of the water would come by filtration from the river. This might change the character of the water somewhat, but probably not enough to produce any marked deterioration of the quality, provided the water were taken from the ground at a distance of one hundred feet or more from the river.

It is not probable that enough water can be obtained by any well or group of wells located in the meadow, where most of the test wells were driven, to supply the town after water has been generally introduced.

If the collecting system were made much more extensive by extending collecting galleries or pipes a long distance up and down the river and up the valley of the brook which serves as an outlet for Lake Martin, a larger supply of water might be obtained, but it seems probable that the supply to be obtained in this way would be exhausted in dry seasons before the works had been in operation for a sufficient length of time to warrant the adoption of this plan. The quality of water to be obtained by this plan might be

as good as that of water taken from the ground in the manner first described; but no definite statement can be made upon this point without more exact information as to the character of the ground into which the collecting system would be extended by this second plan.

There is still another plan for taking water from this locality which has been considered; namely, one in which, in addition to the collecting works just described, with such further additions as might prove necessary for carrying out the plan, water would be pumped from the river, to be distributed upon properly prepared high porous land, where it would filter into the ground, to be intercepted subsequently by the collecting system and conveyed to the main pump well after it had been purified by filtration through the ground. There is little doubt that a water of good quality could be obtained in this way, although much would depend upon the design of the works for filtering the water, and the care taken in the operation of the works to insure the filtration of all of the water and to limit the quantity filtered through any portion of the ground to the amount which it could thoroughly purify.

Taking into account the first cost of this complicated system of works, the yearly cost of operating thém in such a way as to obtain a sufficient supply of good water and the uncertainty as to the results which would be obtained, it does not seem advisable to adopt this plan, when you may obtain from Upper Naukeag Pond, by a simple plan and probably with a much smaller annual cost, an ample supply of water of good quality.

The Board, in its reply, dated April 6, 1894, to a previous application made by you relative to the investigations that you had better make with regard to finding a suitable water supply for the town of Winchendon, suggested, in addition to the Upper Naukeag Pond plan, that you should investigate among other sources the feasibility of taking a water supply from the Stone Lot source, supplemented by water from Beaman Brook. You have sent us from this brook a sample of water collected on April 24, 1894, which had a deep brownish color, such as water acquires from contact with vegetable matter in swampy places. As far as can be judged from the analysis of a single sample of water, this source would not furnish a water of sufficiently good quality to make it an appropriate source of water supply for the town.

In the reply already referred to, the Board stated that with the information which it then had it believed "Upper Naukeag Pond to be an appropriate source of water supply for the town of Winchendon, unless some equally good cr better source can be found nearer the town." The information which you have furnished

regarding the Prentice Meadow source, and the further information now available regarding the quality of the water to be obtained from the Beaman Brook and Stone Lot source, do not indicate that either of these sources will furnish an equally good or better supply of water than can be obtained from Upper Naukeag Pond.

With its present information the Board is of the opinion that Upper Naukeag Pond is the most appropriate source of water supply for the town of Winchendon.

A further communication was received from the water committee of Winchendon, dated Aug. 6, 1894, asking the Board, "what, in their opinion, is the minimum amount of water per day that the Prentice Meadow would yield, without pumping from the river." The Board replied as follows: —

Sept. 10, 1894.

There are two ways in which the quantity of water to be obtained from the ground in any given locality may be estimated. One is to ascertain the results obtained at other places somewhat similarly situated, and to use these results as a basis for estimating the quantity of water to be obtained from the proposed source. As no two cases are exactly alike, it is necessary to make due allowance for differences in the character of the ground, the size of the water-shed, the presence or absence near the ground-water source of a large stream or body of water, and for other conditions which may affect the quantity of water.

In investigating the capacities of the various ground-water sources in Massachusetts, it is very noticeable that in cases where ledge is encountered at the moderate depth at which it was found by test wells in a large part of the Prentice Meadow, the quantity of water obtainable is much smaller than where the porous material extends to a much greater depth.

There are eight sources in Massachusetts where ledge is encountered at about the same depth beneath the surface of the ground as at the Prentice Meadow. According to the best information now available, the capacity of these sources in the driest years ranges from 50,000 gallons per day for the smallest to 155,000 gallons per day for the largest. In some of these cases the conditions apart from the presence of the ledge are decidedly less favorable than at the Prentice Meadow; so that, judging by the experience in other places, it seems probable that wells at the Prentice Meadow would furnish the larger rather than the smaller quantity obtainable from the wells referred to.

The second way of estimating the quantity of water to be obtained from the ground takes into account the area of water-shed tributary to the location of the well or wells, the amount of storage capacity in the interstices of the ground which may be made available by the lowering of the water in the ground during the drier portions of the year, and the area of river bottom in the vicinity of the wells from which water may percolate into the ground to replace that pumped from it. Upon this basis the engineers of the Board have estimated that a well or wells in the Prentice Meadow would yield during the driest four months of a dry year about 130,000 gallons per day.

In the case of a ground-water supply it is not feasible to determine the quantity of water to be obtained with nearly as much accuracy as in the case of a surface-water supply, because the character of the ground from which the water is to be drawn is not accurately known, even after as extended tests as you have made. While, therefore, the Board estimates that the quantity of water to be obtained from a well or group of wells in the Prentice Meadow would be from 100,000 to 200,000 gallons per day, it cannot be at all definitely stated that the quantity may not be even more or less than these figures.

Sewerage and Sewage Disposal.

The following is the substance of the action of the Board in reply to applications for advice relative to sewerage and sewage disposal: —

Andover. An application was received from the sewer commissioners of Andover Feb. 8, 1894, for the advice of the Board relative to certain plans of sewage disposal for that town. To this application the Board replied as follows: —

March 2, 1894.

The plan accompanying your application shows a system of pipe sewers to provide for the sewerage of all of the thickly settled portions of the town, and to collect the whole of the sewage at a point on Lowell Street east of the Shawsheen River. From this point three different plans are referred to in the report of your engineers, as follows: one providing for the discharge of the sewage, after it has been passed through a settling tank, into the Shawsheen River, about 1,200 feet below Lowell Street; another for conveying the sewage through a twenty-four inch pipe from Lowell Street to the Merrimack River at North Andover; and the third for pumping the sewage to filter beds located north-westerly from Frye Village.

You state in your application that you desire to adopt the first of these plans, which provides for an outlet into the Shawsheen River; and in a subsequent communication you make the further statement that it is proposed in the beginning to build sewers for only a small portion of the town, as indicated upon an accompanying plan.

The Board has not sufficiently investigated the plans submitted to enable it to advise as to the best method for the permanent disposal of the sewage of the town, although, judging from the report of your engineers, it seems probable that it will be best to discharge the sewage into the Merrimack River.

As you desire a prompt answer to your proposition to use in the beginning an outlet into the Shawsheen River, about 1,200 feet below Lowell Street, the Board has carefully considered this subject, and concludes that this outlet is not a suitable one for the sewage of the central portion of the town, or for as large a population as will probably be connected with the system within a few years after the works are first operated.

Concord. The committee on sewerage of the town of Concord applied to the Board Nov. 20, 1894, for the advice of the Board upon a proposed plan of sewerage and sewage disposal for that town. The Board replied as follows: —

Jan. 3, 1895.

The State Board of Health received from you a communication dated Nov. 20, 1894, in which you state that the town of Concord passed a vote April 2, 1894, authorizing you "to apply to the next General Court for such legislation as may be necessary and desirable to enable the town to construct and maintain a suitable system of sewerage and sewage disposal in general accordance with the report of the committee made to this meeting;" and you submit with your communication the annual report of the town, containing the report of the committee on sewerage referred to in the said vote, and request the advice and recommendation of the State Board of Health in the premises.

In the report submitted is outlined a proposed plan for the sewerage of the more thickly settled parts of the town by means of a system of pipe sewers leading to a pumping station, at which the sewage will be forced through a pipe to high dry land and there filtered and purified. Judging from the outline presented, the Board believes that the proposed plan is to be commended as one well adapted to the needs of the town of Concord, but can advise

more fully after the more definite plans, which it understands are to be prepared, are presented.

An examination of the land pointed out by you as being available for the disposal of the sewage indicated that it was suitable for this purpose.

The Board is of the opinion that intermittent filtration through land is the proper method of disposing of the sewage of your town.

HAVERHILL. An application was received from the mayor of Haverhill June 22, 1894, for the advice of the Board relative to a proposed sewerage system near Lake Saltonstall, the question being whether a separate or combined system of sewerage would be preferable, under the circumstances, and as to the disposal of the sewage of a part of the city near Dustin Square. The Board replied as follows: —

AUG. 21, 1894.

The State Board of Health received from you a communication dated June 22, 1894, in which you state that petitions have been presented to the city council asking for a sewerage system in the vicinity of Lake Saltonstall, one of your sources of water supply; and you ask the opinion of the Board as to whether the separate or combined system of sewerage is preferable under the circumstances. You also ask with regard to the disposal of the sewage of another section of the city near Dustin Square, suggesting that it may require the separate system, with filter beds.

The State Board of Health has caused these subjects to be carefully considered by its engineers. It finds that the proposed system in the vicinity of Lake Saltonstall is intended to provide for the territory bordering upon the westerly half of the lake.

In order that there may be no misunderstanding of terms, a "combined" system will be defined as one in which the sewage proper and the storm water flowing from streets and other surfaces during storms are conveyed away in one sewer, while a "separate" system is one in which the sewage proper is carried away in one conduit, generally a pipe of moderate size, while the storm water is removed by a much larger conduit. Very heavy storms furnish an amount of water very many times as great as the amount of sewage proper; so that, if all of the water during the heaviest storms is to be conveyed away by the sewers or drains, they must be very large as compared with the pipe for taking sewage only from the same district. It is consequently customary, wherever

practicable, to provide an overflow for the discharge of the surplus storm water, so as to diminish the cost of the works.

This practical consideration with regard to the size of the conduit for carrying the storm water makes the question of the length of time that Lake Saltonstall will be used as a source of water supply an important one. If it is to be retained as a source of water supply, the sewers of a combined system should be large enough to take the water flowing off during the heaviest storms, so that there will be no overflow of sewage into the lake. If the use of the lake for water-supply purposes should be discontinued, the main sewer of the combined system might be a little smaller, but it should still be large, so that such overflow would take place only at very rare intervals. If the separate system should be used, the sewage would not overflow into the lake, because the quantity would not increase materially during rains, and the storm water in a separate conduit might overflow occasionally without doing any serious harm. Consequently, with the separate system, the storm-water conduit from Mill Street to the outlet of the lake might be much smaller than the corresponding sewer of the combined system.

There is a third solution of the problem, using in part the separate system and in part the combined system, which may be more satisfactory than either of the others. By this plan the separate system would be used to bring the sewage and storm water from most of this territory to the low point in Mill Street near the westerly end of the lake, and from this point the sewer along the shore of the lake to its outlet would be built as a combined sewer to take both the sewage and storm water. In this case, however, the combined sewer might be a comparatively small one, as the surplus storm water of heavy storms could be permitted to overflow into the lake before entering this sewer. By this plan the sewers down to the low point on Mill Street would cost more than the sewers of the combined system, but below this point would cost much less.

Any one of the three plans, if designed and constructed as indicated, would be satisfactory from a sanitary point of view; and the question as to which should be adopted may properly depend upon their relative cost, which your engineer has better opportunities for determining than the engineers of this Board.

The best method of disposing of the sewage of the section of the city near Dustin Square has been considered by the Board, and after making examinations with regard to the purification of the sewage by filtration through sand, with the subsequent discharge of the effluent from the filter beds into Little River, it has con-

cluded that it would be better and cheaper to convey this sewage to the Merrimack River through an extension of the present Hilldale Avenue sewer or some other sewer in the valley of Little River.

HUDSON. The sewerage committee of the town of Hudson applied to the Board March 24, 1894, submitting to the Board the following questions relative to a proposed system of sewerage and sewage disposal for that town: —

1. Will the town be permitted to drain the whole or a part of its sewage into the Assabet River; and, if a part, what part?

2. What is the best location for its filter beds, if not permitted to drain into the river?

3. If filter beds should be necessary, what will be the best practicable method of constructing them?

To these inquiries the Board replied as follows: —

MAY 3, 1894.

"1. Will the town be permitted to drain the whole or a part of its sewage into the Assabet River; and, if a part, what part?

"2. What is the best location for its filter beds, if not permitted to drain into this river?

"3. If filter beds should be necessary what will be the best practicable method of constructing them?"

The Board has carefully considered the question of the effect of discharging sewage from the town into the river, and is of the opinion that no considerable part of the sewage of the town could be discharged into the stream without having an injurious effect; and it is desirable that a system should be adopted which would wholly prevent the discharge of sewage into the river.

The best method of purifying the sewage of a town is by intermittent filtration through porous sand or gravel, where such material can be found; and the examinations indicate that such material, quite favorably located, may be found in the town of Hudson, so that this is the best method for adoption in your case.

With regard to the best location for filter beds, it is not feasible to advise definitely without further knowledge as to the relative height of the town and of the land which might be used for filtration. There is land on both sides of the river, about a mile below the town, which appears to be suitable for intermittent filtration. This land is located on the easterly side of the first road which crosses the river below the Massachusetts Central Railroad. If

the sewage of the town could be brought by gravity to this locality, so that it would be six or eight feet above ordinary high water in the river, beds might be prepared at this level upon which the sewage could be filtered; but the preparation of such beds would involve considerable expense for filling and underdrainage, and on account of this expense the area of the beds might be more limited than would be desirable. If, however, the sewage should be pumped to higher land, there would be a greater certainty of successful purification, the cost of preparing the beds would be much smaller and there would be an ample area of land for future extension.

The amount of land which should be prepared for filtration in the beginning cannot be definitely told with the present information, but it would probably be between four and eight acres. The amount will depend upon the character of the material and the height of the land above the ground water, both of which can be determined by digging test pits. It is often desirable, where land is cheap and is so situated that it can be prepared for sewage filtration at a comparatively small cost, to prepare a greater area of filter beds than is absolutely necessary, so as to insure the purification of the sewage at all seasons of the year, and so that the surface of the beds may be less liable to clog than if a large amount of sewage was deposited upon a comparatively small area. Liberal provision should be made for future wants by acquiring in the beginning sufficient land upon which to construct additional filter beds from time to time, as they are made necessary by an increase in the number of people connected with the sewers.

The town of Framingham acquired about seventy acres, and prepared about twelve acres for the filtration of the sewage of South Framingham. This has proved to be an ample area for disposing of the sewage, but the town has recently prepared additional beds, with a view to raising crops upon them. The whole of the town of Framingham contained 9,239 inhabitants in 1890.

The city of Marlborough (population in 1890, 13,805) purchased about sixty-three acres, and prepared 11.3 acres for the disposal of sewage. In this case there has been a little difficulty in disposing of the sewage in very cold winters, and when an unusual amount of ground water found its way into the sewers in the spring, which might have been avoided if additional land had been prepared for filtration. It is probable that extensions will have to be made before long.

In both of these cases the land is porous, and of very good quality for sewage filtration.

The Board will advise you further in this matter when you have further information to present.

Milton. An application was received from the committee on sewerage of Milton May 2, 1894, for the advice of the Board relative to a system of sewerage for that town, having outlets into the Dorchester intercepting sewer of the City of Boston. To this application the Board replied as follows: —

Sept. 25, 1894.

The main features of the proposed plan, as indicated by the written description and the plan accompanying your application, are systems of pipe sewers from which storm water is to be excluded, for collecting the sewage of the town and conveying it to the Dorchester branch of the main sewerage system of the city of Boston, and underdrains beneath nearly all of the sewers for collecting the ground water and conveying it to the Neponset River.

Upon the plan three sewer districts are shown, each having an independent connection with the Boston sewer, and in addition to these the description refers to a fourth district, including the village of Milton Lower Mills, in which no sewers are shown upon the plan, but which is now partially provided with sewers which discharge into the Neponset River. It is stated that the system for this district is to be connected with the Boston sewer, and it is also stated that the town has secured the consent of the mayor of Boston to this method of disposing of the sewage of Milton, and that he has named a price per year for such disposal, which is satisfactory to the town committee.

The Board is of the opinion that the method of disposing of the sewage of Milton by discharging it into the main sewerage system of the city of Boston is the best that can be adopted, and that this method should be made to apply to all portions of the town, including the village of Milton Lower Mills.

The engineers of the Board have examined in a general way the locations, sizes and grades of the main sewers, and see no reason to doubt that a system designed substantially, as proposed, if constructed with care, can be made to operate in a satisfactory manner. Some of the sewers necessarily have a low grade, and will require more care in order to keep them clean than if it were feasible to give them a higher grade.

The amount of fall from the end of the fifteen-inch sewer in Granite Avenue on the Milton side of the Neponset River to the Dorchester intercepting sewer is sufficient to render operative a properly designed inverted siphon across the Neponset River at this place. The application states that this inverted siphon is to consist of two ten-inch cast-iron pipes, so arranged that one will

take the ordinary flow and the other the surplus; and the suggestion has since been made, verbally, that the diameter of these pipes might be reduced to eight inches. It is desirable that at least one of the pipes should be made ten inches in diameter, and that both the siphon pipes and the short section of sewer leading from them to the Dorchester intercepting sewer should be placed low enough so that practically the whole difference in level between the sewage in the sewer on the Milton side of the Neponset River and in the Dorchester intercepting sewer may be made available for cleansing the siphon pipes. In this case, as in the case of the sewers of low grade, the works must be maintained with care in order to insure satisfactory results.

While a siphon is a feature not to be included in a sewerage system where it can be readily avoided, there seems to be no alternative in the present case except to pump the sewage, and this would cost much more than the proper maintenance of a siphon.

At Central Avenue the use of a siphon is avoided, as the plans provide for suspending the sewer from the existing bridge.

In regard to the other two crossings, no opinion will be given at the present time, because for the one at Milton Lower Mills no plans have been submitted, and at Mattapan the elevation of the proposed extension of the Dorchester intercepting sewer has not yet been determined.

The provision for removing the ground water by means of drains laid beneath the sewers is to be commended both on account of the sanitary benefits to be derived from keeping the ground thoroughly drained and because of the smaller amount of sewage which will be discharged into the Boston system. It has been found by experience that where there are no underdrains much of the ground water finds its way into the sewers, even when they are constructed with much care, so that in many places the volume flowing in the sewers is two or three times the volume of sewage proper. As this ground water, if collected in separate pipes, can be discharged into the Neponset River without doing harm, it is much better that it should be disposed of in this way than by turning it into the Boston system, not only on account of the cost of pumping the added ground water, but because the Boston system will be overburdened and require duplication much sooner if care is not taken to prevent the entrance of ground water into the sewers connected with it.

Experience in Framingham, Newton and Brockton has shown that it is feasible, by taking sufficient care in the construction of the sewers and underdrains, to prevent the sewage from leaking into these drains to contaminate the ground water, and, indirectly, the streams into which the underdrains discharge.

NANTUCKET. The sewer commissioners of Nantucket applied to the Board June 21, 1894, for its advice relative to a proposed extension of the Lily Pond Drain, so-called, to an outlet at the end of Brant Point. The Board replied as follows: —

SEPT. 10, 1894.

The State Board of Health has carefully considered your application, dated June 21, 1894, and the accompanying plans with regard to the proposed extension of the Lily Pond drain to an outlet about twenty-eight feet beyond mean low-water mark at the extreme end of Brant Point.

The plans submitted show that a catch-basin for intercepting substances that are either lighter or heavier than water is to be built upon the sewer before it reaches the land upon which the Brant Point lighthouse is situated.

The Board has considered the question of this outlet with reference to the quantity of sewage which now flows in the Lily Pond drain, and is of the opinion that the discharge of this amount of sewage at the proposed outlet, after it has had removed from it as much of the heavier and lighter matters as can be retained by a suitably constructed catch-basin, will not cause any serious trouble in the next few years. If the sewage should be discharged without the removal of the solid matters by a catch-basin suitably designed and maintained, it is not unlikely that floating matters would be cast upon the shore between the Nantucket House and the shore end of the westerly jetty, or on the shore of the inner harbor.

The Board believes that it would not be advisable to increase the amount of sewage discharged at this outlet, and that the town should take measures for the introduction of a general system of sewerage, disposing of the sewage by the best available method.

NORTH ANDOVER. An application was received May 28, 1894, from the selectmen and road commissioners of North Andover, for the advice of the Board relative to the propriety of entering a sewer from Main Street, North Andover, into the Merrimack River. The Board replied as follows: —

AUG. 3, 1894.

This plan shows a system of pipe sewers for the main village of North Andover, and indicates that the sewage of the village of North Andover Centre may be brought into the same system through a twelve-inch pipe. The lower end of the Main Street sewer is to be twenty inches in diameter, and is to serve as the main outlet of the system.

The Board is of the opinion that it is permissible for the present to discharge the sewage of the town of North Andover into the Merrimack River at Main Street, but advises that the sewage should be carried out into the river through a submerged pipe as far as practicable beyond low-water mark, in order that it may be diluted quickly, and that there may be less danger of fouling the shores of the river below the outlet.

PALMER. An application was received from the selectmen of Palmer May 11, 1892, for the advice of the Board relative to the disposal of the sewage of the main village of Palmer by direct discharge into the Quaboag River. The reply of the Board, embodying also its reasons for delay in answering the application, was as follows: —

FEB. 1, 1894.

By the proposed plan the sewage is to be collected in a system of pipe sewers from which storm water is to be excluded, and is to be discharged into the Quaboag River below the bridge of the Boston & Albany Railroad Company.

On June 2, 1892, a public hearing upon this question was held at the office of the Board of Health. After this hearing the question was carefully considered by the Board, and it was concluded that it was desirable to defer making a formal reply until definite action had been taken by the city of Chicopee with reference to the abandonment of the Chicopee River as a source of water supply.

The Board is now informed that the works for the supply of water to Chicopee Falls from a new source are completed, and that the use of the Chicopee River as a source of water supply has been discontinued.

As a result of investigations by the engineer of the Board, and a careful consideration of the plan proposed by you and the statements presented at the hearing, the Board concludes that the adoption of a system of sewers from which storm water is excluded is to be commended as being the best adapted to the present and future requirements of the main village of Palmer; and that the sewage may be turned into the Quaboag River below the Boston & Albany Railroad bridge, as proposed, for the present, with the understanding that the sewage is to be diverted from the river and purified whenever the pollution of the stream makes such action necessary. If at any time a public water supply should be taken from the stream at Chicopee or at any other place below Palmer, the necessity for at once diverting the sewage and purifying it would become imperative.

Pollution of Rivers and Sources of Water Supply.

Brookfield. A communication was received March 29, 1894, from H. E. Cottle, Esq., chairman of a committee appointed by the town of Brookfield to investigate the subject of the pollution of Seven-mile River by the town of Spencer, asking the advice of the Board as to the best course to be pursued by the town relative to the nuisance thus caused. The Board replied as follows: —

June 8, 1894.

As you are aware, the town of Spencer applied to the State Board of Health last year for advice with reference to the disposal of its sewage, and in concluding its reply the Board expressed the opinion that the discharge of the sewage directly into the Seven-mile river should be discontinued.

The examinations made at Spencer last year and a further examination made since your communication was received show that a large part of the offence is due to the discharge of wastes from the Spencer Gas Works into the sewers, and thence into the Seven-mile River. It is also essential to the purification of the sewage of the town by intermittent filtration (which is the method under consideration) that the gas wastes should be removed from the sewer. The interception and removal of these gas wastes, so that they would not enter the Seven-mile River, would furnish a large measure of relief during the time when the town is preparing plans and constructing the works for purifying its sewage. The gas wastes from other gas works in the State are now intercepted so that they do not cause a nuisance; and the Board is of opinion that the Spencer Gas Company should provide at once for intercepting the waste matters from its works, so that they will not be discharged into the river.

A copy of this communication will be sent to the Spencer Gas Company.

Deerfield. The selectmen of Deerfield, acting as a Board of Health, complained to the State Board of Health Aug. 13, 1894, that sewage from the town of Greenfield was discharged into the Green River (a stream which flows through the thickly settled part of the town of Deerfield), at or near the boundary line of these towns, and "to the common nuisance of the public and to the detriment of

the public health," at the same time requesting the Board to "take such action and make such orders in relation thereto as the public health and interest demand." The Board replied to this communication as follows: —

Oct. 4, 1894.

The Board caused an examination of the premises to be made by one of its engineers in September, at a time when there was a low flow of water in the streams, and he found that the Green River in Deerfield, and in Greenfield below the outlet of the main sewer, was in an offensive condition, caused mainly by the discharge into it of sewage from the public sewers of the town of Greenfield, but also to some extent by the discharge of sewage and polluting matters from buildings and factories in the town of Deerfield.

In view of the results of his examinations, the Board is of the opinion that this discharge of sewage and polluting matters into this river should be discontinued.

The best plan for disposing of the sewage cannot be definitely determined upon until surveys and other investigations have been made. It seems probable, however, that it will be best to intercept the sewage before its discharge into the Green River, and convey it by means of an intercepting sewer to an outlet discharging well out into the Deerfield River, beyond low-water mark, at some suitable place.

As an intercepting sewer such as is proposed could be used jointly for the disposal of the sewage of both Grenfield and Deerfield, the Board suggests the advisability of joint action, both in the investigation of the matter and in the construction of works for preventing the pollution of the Green River.

A copy of this reply will be sent to the Board of Selectmen of the town of Greenfield.

Framingham. A communication was received from the Board of Health of Framingham June 13, 1894, requesting the State Board of Health "to examine the condition of a portion of the Sudbury River running through Saxonville," and certain meadows in Framingham and South Framingham. The Board, after making the examination, replied as follows: —

Aug. 7, 1894.

Certain insanitary conditions exist in and along the Sudbury River in Saxonville and below that village, tending to impair the health of the inhabitants of the adjacent territory; that the man-

ner of disposing of the waste resulting from the washing of wool in the mill, the method of managing the sink drainage from various dwelling-houses adjacent to the river, the want of due care in the construction, maintenance and use of the ditches in the meadows described in the application are all objectionable; that, while it cannot be demonstrated that these objectionable conditions are the direct cause of malaria, they are sufficiently serious to menace the public health; and, finally, that in the opinion of the State Board of Health they are remediable conditions, and, under the ample authority of the Public Statutes, they are entirely within the control and jurisdiction of the local Board of Health of Framingham.

ROCKPORT. A communication was received July 3, 1894, from the water commissioners of Rockport, asking the Board to notify the owners of a glue factory located upon the water-shed of the Rockport water supply (Cape Pond) to cease polluting the water supply. The Board replied as follows: —

AUG. 3, 1894.

This Board, in a communication dated Feb. 18, 1893, addressed to the selectmen of Rockport, Henri N. Woods and others, expressed the opinion that there was an increasing pollution of the pond by the waste matters from the glue factory, and that if this pollution were stopped the water would in time become of satisfactory quality for the supply of the town. Samples of water collected in 1894 do not show any improvement in the character of the water as compared with a sample collected in February, 1893, and an examination made by the Board shows that the drainage from this factory still finds its way into the pond.

The Board, therefore, has no reason to change its views as to the relation of the drainage from this factory to the quality of the water in the pond, and is of the opinion that, as this pond is to be used to supply the town of Rockport with water, the pollution of the water of the pond by the waste matters from the glue factory should cease forthwith.

The Board is not authorized to notify the proprietors of the glue factory to cease from polluting this pond, but sends for your information a marked copy of the general laws relating to the pollution of sources of water supply.

WORCESTER. A communication was received from Mr. F. B. Smith of Worcester, June 20, 1894, relative to proposed restrictions upon a tract of land in Holden, the larger part of which lies upon the water-shed of a proposed storage

reservoir of the City of Worcester, asking the advice of the Board as to the question of building cess-pools upon the water-shed of the reservoir, and at what distance from the water line it would be safe to construct them. The Board replied as follows: —

AUG. 3, 1894.

The State Board of Health received from you a communication dated June 20, 1894, relative to a certain tract of land in Holden owned by you and Mr. Lincoln Kinnicutt, the larger part of which lies upon the water-shed of a proposed water-supply reservoir of the city of Worcester. You refer to proposed restrictions upon this land, with a view to preventing the pollution of the Worcester water supply by the use which may be made of the land, and in the concluding paragraph ask "whether any tests have been made in regard to the effect of percolation through the soil, and, if the matter has been determined by tests, what distance is necessary to purify sewage by percolation;" also, "how near would it be safe to build cess-pools to the water line of the city's reservoir."

The Board is not aware that any tests have been made for the special purposes of ascertaining how far away from a cess-pool the water from it becomes purified by its passage through the ground. The distance would undoubtedly depend to a very great extent upon many local conditions, such as the depth from the bottom of the cess-pool to the level of the ground water, and the character of the material through which the liquid from the cess-pool filters. The conditions would be less favorable if the sewage percolates in a somewhat concentrated stream in one direction than if it were diffused to a greater extent as it passes through the ground.

Although there have been no special tests in regard to the purification of sewage by its percolation from cess-pools, yet there is much information bearing upon this point. Nearly every well in a thickly settled village derives more or less of its supply by percolation from cess-pools in the vicinity, and yet in a majority of cases the degree of purification effected by filtration is such that the water of the wells is used for drinking purposes.

In South Framingham, Newton and Brockton underdrains have been laid beneath the sewers to carry off the ground water, and before any sewage had been turned into these sewers samples of water were collected from the underdrains and analyzed. The common method of disposing of the sewage of these places at the time was by means of cess-pools, and the analyses of the water from the underdrains left no doubt that it came in part from these sources.

The Board has already advised the town of Framingham with regard to the character of the water of its underdrain and its relation to the water supply of the city of Boston, into which it was and is now discharged; and, as there is some similarity between this case and your own, a copy of the reply of the Board to the town of Framingham is enclosed herewith.

The distance through which the liquid from a cess-pool must percolate in order to remove the objectionable matters depends upon local conditions to such an extent that with present information it is impracticable to make a general statement of the distance from a reservoir that a cess-pool must be placed in order to insure safety. But under very favorable conditions of soil the filtration of sewage from a small number of cess-pools to a storage reservoir two hundred feet distant would not be likely to have a noticeable effect upon the quality of the water supplied from the reservoir.

EXAMINATION OF WATER SUPPLIES.

EXAMINATION OF WATER SUPPLIES.

EXPLANATORY NOTE.

The systematic examination of the water supplies of the State was begun June 1, 1887, and has been continued up to the present time. The results for the first two years were published in a special report of the Board upon the Examination of Water Supplies (1890), and for the succeeding years in the annual reports of the Board beginning with the 1890 (Twenty-second Annual) report.

The special report contains a description of each of the water supplies in the State existing at the date of that report, and the annual reports only contain descriptions of new works and changes in existing works.

In all of these reports an alphabetical arrangement by towns has been adopted. Sources of water supply are tabulated under the name of the town supplied, other waters under the name of the town in which they are situated. The analyses of water from the larger rivers not used as sources of water supply are given in a subsequent tabulation, headed "Examination of Rivers."

The method of making the chemical and microscopical examinations remains unchanged, and the results are presented in the tables of this report in the same form as in the last one.

The samples of water are usually received at the laboratory from twenty-four to forty-eight hours after collection. All surface water and such samples of ground water as contain suspended matter are filtered through filter-paper before determining the color, the residue on evaporation and the albuminoid ammonia in solution. Some ground waters which are perfectly clear and colorless when drawn from the ground become turbid and colored on standing, in consequence of the oxidation of the iron which they contain. In these waters the residue on evaporation is determined without filtration, since this iron is an essential and not an accidental ingredient in the water. In the changes which accompany the oxidation of the iron in waters of this character, they become first cloudy (well described by the word *milky*) and finally deposit a precipitate of oxide of iron. In the cloudy condition they have a distinct color, which, while it does not have the same significance as in the case of surface waters, and is only a passing phenomenon, is, nevertheless, of interest as showing a color which the water may assume while the oxidation of the iron is in progress. When the iron is all oxidized and precipitated the water may become colorless again. Explanatory notes will be given for waters of this kind in connection with the tables of analyses.

The color of water is expressed by numbers which increase with the amount of color. The standard used is nesslerized ammonia, as described on page 531 of the Special Report upon the Examination of Water Supplies, 1890, and on page 329 of the Annual Report for 1893. Boston water, as drawn from a tap at the Institute of Technology, had an average color in 1894 of 0.69. Other water supplies in the State have had an average color of from 0 to 1.45.

In cases where examinations of a source have been made with considerable regularity for several years, the averages of the chemical analyses of each year are given.

In the microscopical examination of water there has been no change in the method employed since Nov. 6, 1890. This method was fully described in the Twenty-third Annual Report of the Board for the year 1891 (pages 395–421). Before Nov. 6, 1890, the methods employed were less perfect, so that a smaller proportion of the total number of organisms present in the water was separated from it and observed under the microscope; and, before drawing conclusions from a comparison of the microscopical examinations of waters made before and after this date, the explanatory note on page 70 of the Twenty-second Annual Report for 1890 should be read.

To indicate the amount of the so-called *Zoöglœa* observed, the number of individual masses is not counted, but an area equal to 2,500 square microns, or .0025 square millimeters, has been adopted as an arbitrary unit.

In publishing the results of the microscopical examinations the same system is followed as last year. The plants observed are classified in four groups, viz.: Diatomaceæ, Cyanophyceæ, Algæ and Fungi. The Animals observed are grouped as Rhizopoda, Infusoria, Vermes and Crustacea.

The names of the different genera in each group are given with the numbers of each per cubic centimeter, except that, to avoid making the tables excessively long, they are omitted when present only in very small numbers. It is not feasible to make with regard to omissions a single rule which will apply to all cases, because it is desirable to include smaller numbers of animals than of plants, and of the larger animals than of animals generally. Moreover, there are exceptional cases in which it is desirable to indicate the presence of even very small numbers of the more important plants or animals. Two general rules, however, have been adopted in printing the results, namely: —

1. All genera of Plants are included in which the total number observed in twelve months amounts to 6 or more per cubic centimeter, or, in other words, averages as much as 0.5 per month.

2. All genera of Animals are included in which the total number observed in twelve months amounts to 1.5 or more per cubic centimeter.

The larger microscopic animals, such as some of the Crustacea, are included, even when present only in very small numbers.

Fractions are generally omitted from the table, the nearest whole number of organisms per cubic centimeter being given. Where the total number of organisms observed is 0.5 or less, the fact that the organism was present is usually indicated by the abbreviation "pr.," but in the case of the larger organisms very small fractions are given.

EXAMINATION OF WATER SUPPLIES.

Water Supply of Abington and Rockland.

Chemical Examination of Water from Big Sandy Pond, Pembroke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11878	Mar. 12	Slight.	Cons.	0.03	2.75	1.00	.0004	.0148	.0116	.0032	.61	.0050	.0000	.1896	0.2
12026	Apr. 10	V. slight.	V. slight.	0.05	2.75	1.00	.0002	.0114	.0102	.0012	.63	.0050	.0000	.1564	0.2

Averages by Years.

-	1887*	-	-	0.20	3.45	0.94	.0008	.0150	-	-	.58	.0056	-	-	-
-	1888†	-	-	0.10	3.23	0.82	.0006	.0164	-	-	.55	.0073	.0001	-	-
-	1892‡	-	-	0.10	4.30	-	.0000	.0200	.0150	.0050	.59	.0090	.0000	-	0.5
-	1893	-	-	0.07	3.19	1.19	.0010	.0146	.0122	.0024	.63	.0012	.0000	.2130	0.5
-	1894	-	-	0.04	2.75	1.00	.0003	.0131	.0109	.0022	.62	.0050	.0000	.1730	0.2

* June to October, six samples. † January to April, five samples. ‡ March.

Note to analyses of 1894: Odor of the first sample, distinctly vegetable and unpleasant, becoming stronger on heating; of the second, faintly vegetable and sweetish. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No. 11878. Diatomaceæ, *Asterionella*, 20; *Cocconema*, 1; *Cyclotella*, 18; *Diatoma*, 1; *Melosira*, 6; *Synedra*, 60; *Tabellaria*, 30. Algæ, *Arthrodesmus*, 11; *Protococcus*, 9; *Staurogenia*, 2. Infusoria, *Dinobryon cases*, 2; *Peridinium*, 1. Vermes, *Polyarthra*, 2 Miscellaneous, *Zoöglœa*, 20. Total, 183.

No. 12026. Diatomaceæ, *Asterionella*, 6; *Cyclotella*, 16; *Diatoma*, 1; *Nitzschia*, 1; *Synedra*, 1; *Tabellaria*, 17. Cyanophyceæ, *Merismopedia*, 2. Algæ, *Arthrodesmus*, 1; *Protococcus*, 25; *Scenedesmus*, 1. Infusoria, *Dinobryon cases*, 4. Crustacean remains, .03. Total, 75.

AMESBURY.

WATER SUPPLY OF AMESBURY. — POWOW HILL WATER COMPANY.

Chemical Examination of Water from Tubular Wells supplying Open Basins near Main Street.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1894.												
12611	July 25	Slight, milky.	None.	0.12	10.50	.0002	.0000	.49	.0020	.0000	.0031	5.4	.0400
12612	July 25	Distinct.	Slight, green.	0.04	9.20	.0000	.0078	.56	.0120	.0000	.0516	4.2	.0200
13041	Sept. 28	Slight.	V. slight.	0.08	8.80	.0004	.0090	.58	.0300	.0001	.0520	3.6	.0300
Av.	....	....	....	0.08	9.50	.0002	.0056	.54	.0147	.0000	.0356	4.4	.0300

Odor of the first sample, none; of the second, distinctly disagreeable, becoming less strong on heating; of the third, decidedly vegetable and disagreeable. —— The samples were collected at the pumping station on Main Street.

Microscopical Examination.

No. 12611. No organisms.

No. 12612. Algæ, *Scenedesmus*, 32. Infusoria, *Cryptomonas*, 150. Total, 182.

No. 13041. Diatomaceæ, *Tabellaria*, 2. Algæ, *Protococcus*, 632; *Scenedesmus*, 16. Miscellaneous, *Zoöglœa*, 70. Total, 720.

Chemical Examination of Water from Thirty-six Tubular Wells near Market Street, used as a Supplementary Source of Supply.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1894.												
12613	July 25	None.	None.	0.03	19.40	.0026	.0008	1.20	.0020	.0000	.0000	12.1	.0180
13042	Sept. 28	None.	None.	0.04	20.50	.0030	.0006	1.24	.0000	.0002	.0160	12.7	.0050

Odor none. —— The samples were collected at the pumping station on Market Street.

Microscopical Examination.

No. 12613. No organisms.

No. 13042. Miscellaneous, *Zoöglœa*, 5.

AMHERST.

Water Supply of Amherst. — Amherst Water Company.

Chemical Examination of Water from a Faucet in the Village.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
18406	1894. Dec. 3	None.	V. slight.	0.75	3.80	1.70	.0000	.0112	.0094	.0018	.16	.0030	.0000	.6660	0.6

Odor, none.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 2; *Melosira*, 3; *Synedra*, 1. Total, 6.

Water Supply of Andover.

Chemical Examination of Water from Haggett's Pond, Andover.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11616	Jan. 9	V. slight.	V. slight.	0.10	3.40	1.00	.0010	.0122	.0106	.0016	.31	.0000	.0000	.2730	1.4
11707	Feb. 4	V. slight.	V. slight.	0.05	3.05	1.15	.0020	.0116	.0096	.0020	.36	.0000	.0000	.2976	1.8
11841	Mar. 4	None.	V. slight.	0.10	3.40	1.20	.0006	.0140	.0124	.0016	.35	.0050	.0000	.3084	1.3
11985	Apr. 2	V. slight.	Slight.	0.12	3.50	1.35	.0000	.0110	.0094	.0016	.33	.0030	.0000	.2871	1.1
Av.	....	....	....	0.09	3.34	1.18	.0009	.0122	.0105	.0017	.34	.0020	.0000	.2915	1.3

Averages by Years.

-	1889*	-	-	0.10	5.85	2.70	.0004	.0198	.0170	.0028	.29	.0040	.0001	-	1.1
-	1891†	-	-	0.08	3.35	1.70	.0004	.0136	.0080	.0056	.33	.0030	.0000	-	1.3
-	1892	-	-	0.06	3.20	1.02	.0003	.0175	.0147	.0028	.34	.0051	.0000	-	1.3
-	1893	-	-	0.09	3.30	1.30	.0013	.0151	.0124	.0027	.34	.0020	.0000	.2762	1.2
-	1894	-	-	0.09	3.34	1.18	.0009	.0122	.0105	.0017	.34	.0020	.0000	.2915	1.3

* July. † November.

Note to analyses of 1894: Odor of the first two samples, distinctly vegetable; of the third, none; of the fourth, distinctly vegetable and somewhat unpleasant. —— The samples were collected from a faucet at the pumping station.

ANDOVER.

Microscopical Examination of Water from Haggett's Pond, Andover.

[Number of organisms per cubic centimeter.]

	1894.			
	January.	February.	March.	April.
Day of examination,	10	5	6	4
Number of sample,	11616	11707	11841	11985
PLANTS.				
Diatomaceæ,	32	5	11	65
Asterionella,	7	pr.	0	5
Cyclotella,	16	0	0	4
Epithemia,	0	pr.	0	2
Melosira,	7	0	0	6
Synedra,	2	2	11	46
Tabellaria,	0	3	0	2
Algæ, Protococcus,	0	0	0	5
Fungi, Crenothrix,	1	0	3	0
ANIMALS.				
Infusoria,	8	48	23	56
Dinobryon,	0	1	0	18
Dinobryon cases,	8	46	22	38
Monas,	pr.	0	0	pr.
Peridinium,	0	0	0	pr.
Trachelomonas,	0	1	1	pr.
Vermes,	pr.	0	0	pr.
Monocerca,	0	0	0	pr.
Rotatorian ova,	pr.	0	0	0
Miscellaneous, Zoöglœa,	2	2	0	0
TOTAL,	43	55	37	126

WATER SUPPLY OF ARLINGTON.

The advice of the State Board of Health to the town of Arlington relative to obtaining an additional water supply may be found on pages 7 and 8 of this volume. For analyses of samples of water from the wells mentioned in the reply to the town see the annual report of the Board for 1892, pages 81 and 82, and for 1893, page 97. Works for the supply of the higher portions of the town from wells in the location mentioned in the reply of the Board were nearly completed at the end of 1894.

ARLINGTON.

Chemical Examination of Water from a Faucet in Arlington.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11605	Jan. 5	Slight, milky.	None.	0.20	7.20	.0040	.0072	.78	.0300	.0004	.2964	2.9	.0250

Odor, none. —— The sample was collected from a faucet in the town hall, and represents water from the filter-gallery.

Microscopical Examination.

No organisms.

Ashburnham.

Chemical Examination of Water from Upper Naukeag Pond, Ashburnham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
12095	Apr. 24	V. slight.	Slight.	0.15	1.40	0.65	.0004	.0106	.0084	.0022	.14	.0070	.0000	.2765	0.0
12792	Aug. 21	Slight.	Slight.	0.05	2.00	0.75	.0000	.0088	.0076	.0012	.12	.0060	.0001	.2464	0.1

Averages by Years.

-	1888	-	-	0.13	2.01	0.60	.0002	.0145	-	-	.09	.0045	.0001	-	-
-	1889*	-	-	0.05	1.95	0.85	.0000	.0196	.0134	.0062	.08	.0020	.0000	-	-
-	1890†	-	-	0.03	2.43	1.50	.0003	.0151	.0115	.0036	.08	.0050	.0000	-	0.3
-	1891‡	-	-	0.00	1.90	0.85	.0000	.0122	.0122	.0000	.09	.0030	.0000	-	0.0
-	1892	-	-	0.05	2.00	0.75	.0000	.0106	.0084	.0022	.11	.0050	.0000	-	0.3
-	1893	-	-	0.08	1.67	0.75	.0010	.0094	.0077	.0017	.12	.0010	.0000	.1433	0.2
-	1894	-	-	0.10	1.70	0.70	.0002	.0097	.0080	.0017	.13	.0065	.0001	.2630	0.1

* April. † August. ‡ September.

NOTE to analyses of 1894: Odor, none. —— The samples were collected from the pond, about 4 feet beneath the surface.

Microscopical Examination.

No. 12095. Diatomaceæ, *Asterionella*, 18; *Cyclotella*, 9; *Synedra*, 5; *Tabellaria*, 8. Algæ, *Arthrodesmus*, 1; *Protococcus*, 1; *Staurogenia*, 3. Total, 45.

No. 12792. Cyanophyceæ, *Microcystis*, 2; Algæ, *Tetraspora*, 14. Infusoria, *Dinobryon cases*, 3. Crustacean remains, .02. Miscellaneous, *Zoöglœa*, 11. Total, 30.

ATHOL.

Water Supply of Athol. — Athol Water Company.

During the past three years several changes have been made in the works for supplying the town of Athol with water. Phillipston reservoir, which was formerly from 8 to 12 feet deep over the larger portion of its area, has been improved by raising the main dam and overflow 1 foot, and by building a dike along the westerly and northwesterly side to cut off shallow portions. Material for the construction of the dike was taken from the shallower portions remaining within the reservoir. The southerly side has been improved by excavation and filling so as to make deeper water and a steep shore. The slopes of the dam and dike are paved with field stones. A new pipe has been laid to draw water from the reservoir at a point about 250 feet from the shore.

About 1,000 feet below the dam of the reservoir, a well, 25 by 40 feet inside and 12 feet deep, has been dug in a large, flat meadow, to collect the leakage from the reservoir and ground water. It is proposed to pump this water back into the reservoir through a 6 inch force main when the water in the reservoir is below high-water mark.

Chemical Examination of Water from the Large Reservoir in Phillipston.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11638	Jan. 15	V. slight.	V. slight.	0.90	5.20	1.80	.0002	.0122	.0102	.0020	.14	.0070	.0000	.7371	1.9
11718	Feb 6	None.	V slight.	0.55	3.45	1.10	.0008	.0112	.0098	.0014	.13	.0030	.0003	.6040	0.8
11837	Mar. 5	V. slight.	Slight.	0.40	3.10	1.05	.0000	.0098	.0088	.0010	.10	.0050	.0000	.4584	0.6
11998	April 4	None.	V. slight.	0.50	2.60	0.70	.0000	.0104	.0084	.0020	.09	.0030	.0000	.4042	0.3
12167	May 8	Distinct.	Cons., green.	0.25	2.55	1.20	.0000	.0098	.0070	.0028	.10	.0050	.0000	.4084	0.3
12339	June 8	None.	V. slight.	0.05	2.60	0.85	.0014	.0086	.0060	.0026	.09	.0000	.0000	.1886	1.4
12497	July 9	V. slight.	Slight.	0.25	2.85	0.85	.0070	.0158	.0132	.0026	.10	.0000	.0000	.3696	0.5
12677	Aug. 7	Distinct.	Slight, green.	0.25	2.80	0.90	.0000	.0250	.0150	.0100	.12	.0030	.0000	.3734	0.9
12956	Sept. 12	Decided, green	Cons., brown.	0.50	6.40	–	.0000	.0522	.0122	.0400	.11	.0030	.0000	.2772	0.6
13086	Oct. 4	Decided, green.	Cons.	0.80	5.40	2.40	.0048	.0398	.0266	.0132	.12	.0030	.0000	.8018	1.3
13310	Nov. 14	Slight.	Slight.	0.25	4.05	1.10	.0070	.0058	0048	.0010	–	.0180	.0000	.2691	1.4
13458	Dec. 6	V. slight.	V. slight.	0.75	4.15	1.35	.0014	.0140	.0122	.0018	.10	.0070	.0000	.8085	0.9
Av.	....	....	....	0.45	3.75	1.39*	.0019	.0179	.0112	.0067	.11	.0048	.0000	.4750	0.9

Odor, vegetable or none. —— The samples were collected from the reservoir.

* In making this average the loss on ignition for September was assumed to be 3.40.

ATHOL.

Averages by Years.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
1887*	–	–	–	1.25	4.23	1.89	.0027	.0360	–	–	.16	.0075	–	–	–
1888†	–	–	–	0.80	3.22	1.17	.0010	.0157	–	–	.11	.0127	.0000	–	–
1894	–	–	–	0.45	3.75	1.39	.0019	.0179	.0112	.0067	.11	.0048	.0000	.4750	0.9

* June and December. † January to March.

Microscopical Examination of Water from the Large Reservoir in Phillipston.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	18	7	6	5	9	13	10	8	15	5	15	8
Number of sample,	11638	11718	11837	11998	12167	12339	12497	12677	12956	13086	13310	13458
PLANTS.												
Diatomaceæ,	pr.	5	2	36	12	35	pr.	0	0	2,968	0	3
Cyclotella,	0	1	pr.	0	3	1	pr.	0	0	0	0	0
Melosira,	0	3	1	0	7	4	0	0	0	2,960	0	0
Synedra,	pr.	1	pr.	13	2	30	0	0	0	8	0	2
Tabellaria,	0	0	1	23	0	0	pr.	0	0	0	0	1
Cyanophyceæ, Anabæna,	0	0	0	0	0	0	0	2,080	11,400	152	0	0
Algæ,	0	0	pr.	0	0	0	352	1,700	50	92	0	0
Glœocapsa,	0	0	0	0	0	0	12	1,360	0	0	0	0
Pediastrum,	0	0	pr.	0	0	0	0	0	0	80	0	0
Protococcus,	0	0	0	0	0	0	340	340	0	0	0	0
Scenedesmus,	0	0	pr.	0	0	0	0	0	50	6	0	0
Staurastrum,	0	0	0	0	0	0	0	0	0	6	0	0
Fungi, Crenothrix,	0	1	5	pr.	4	0	0	0	250	10	204	6
ANIMALS.												
Infusoria,	0	1	0	2	3	0	0	1	200	12	0	0
Monas,	0	0	0	0	0	0	0	0	200	0	0	0
Peridinium,	0	1	0	2	3	0	0	1	0	10	0	0
Trachelomonas,	0	0	0	pr.	0	0	0	0	0	2	0	0
Vermes, Rotifer,	0	0	0	0	0	0	0	2	0	0	0	0
Crustacea, Bosmina,	0	0	0	0	0	0	0	0	20	0	0	0
Miscellaneous, Zoöglœa,	0	3	0	0	136	0	0	0	0	0	0	0
TOTAL,	pr.	10	7	38	155	35	352	3,783	11,920	3,234	204	9

ATTLEBOROUGH.

Water Supply of Attleborough.

Chemical Examination of Water from the Well of the Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11631	Jan. 15	None.	None.	0.00	4.00	.0000	.0000	.40	.0250	.0000	.0101	1.9	.0040
11778	Feb. 14	None.	None.	0.00	3.90	.0000	.0004	.38	.0250	.0000	.0360	2.5	.0040
11890	Mar. 14	None.	None.	0.00	3.85	.0004	.0030	.36	.0300	.0000	.0480	1.6	.0050
12066	Apr. 17	None.	None.	0.01	4.00	.0000	.0012	.37	.0230	.0000	.0413	1.8	.0100
12226	May 15	None.	None.	0.02	3.70	.0002	.0024	.35	.0200	.0000	.0546	1.3	.0050
12401	June 19	None.	None.	0.02	4.00	.0002	.0002	.36	.0030	.0000	.0231	1.7	.0040
12533	July 16	None.	None.	0.05	3.50	.0006	.0012	.38	.0150	.0000	.0385	1.6	.0060
12772	Aug. 16	None.	None.	0.02	3.80	.0004	.0004	.30	.0130	.0000	.0500	2.3	.0040
12963	Sept. 17	None.	None.	0.04	4.50	.0000	.0000	.34	.0150	.0000	.0308	1.9	.0050
13170	Oct. 18	V. slight, milky.	V. slight.	0.02	4.10	.0002	.0024	.36	.0120	.0000	.0474	1.7	.0030
13314	Nov. 15	None.	None.	0.01	4.80	.0000	.0028	.45	.0220	.0000	.0359	1.8	.0010
13485	Dec. 13	None.	None.	0.03	3.60	.0000	.0028	.44	.0280	.0000	.0077	1.6	.0000
Av.	....	....	....	0.02	3.98	.0002	.0014	.37	.0193	.0000	.0353	1.8	.0043

Odor, none. —— The samples were collected from a faucet at the pumping station, while pumping.

Microscopical Examination.

No. 11890. Zoöglœa, 3.

No. 12963. Fungi, *Crenothrix*, 4. Miscellaneous, *Zoöglœa*, 5. Total, 9.

In the remaining samples no organisms were found.

Auburn.

Chemical Examination of Water from Dark Brook and Stoneville Reservoir, Auburn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13223	Oct. 26	V. slight.	Slight.	1.90	10.85	3.75	.0002	.0270	.0250	.0020	.73	.0050	.0001	1.4141	3.6
13224	Oct. 26	Distinct.	Cons.	1.10	6.95	2.40	.0038	.0330	.0304	.0026	.35	.0050	.0001	.9835	2.1

Odor of the first sample, distinctly vegetable; of the second, decidedly vegetable and sweetish. —— The first sample was collected from Dark Brook, the second from Stoneville Reservoir, while making an examination of possible sources of water supply for the city of Worcester.

Microscopical Examination.

No. 13223. Diatomaceæ, *Epithemia*, 1; *Synedra*, 3. Fungi, *Beggiatoa*, 1; *Crenothrix*, 38. Total, 43.

No. 13224. Diatomaceæ, *Diatoma*, 15; *Epithemia*, 1; *Gomphonema*, 1; *Melosira*, 5; *Pinnularia*, 1; *Surirella*, 2; *Synedra*, 44; *Tabellaria*, 4. Algæ, *Raphidium*, 4; *Scenedesmus*, 1. Fungi, *Crenothrix*, 4. Infusoria, *Peridinium*, 4. Total, 86.

Water Supply of Avon.

Chemical Examination of Water from the Well of the Avon Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1894.												
12934	Sept. 12	V. slight.	V. slight.	0.03	5.20	.0000	.0014	.41	.0300	.0000	.0000	1.4	.0100

Odor, none. —— The sample was collected from a faucet at the pumping station.

Microscopical Examination.

No organisms.

AYER.

WATER SUPPLY OF AYER.

Chemical Examination of Water from the Well of the Ayer Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
12092	Apr. 23	V. slight.	None.	0.03	5.00	.0000	.0010	.41	.0680	.0000	.0158	2.1	.0350
12629	July 30	None.	None.	0.00	5.50	.0000	.0004	.42	.0730	.0000	.0023	2.5	.0040
12796	Aug. 21	None.	None.	0.00	3.25	.0000	.0002	.36	.0700	.0000	.0077	2.7	.0100
Av.	....	....	....	0.01	4.58	.0000	.0005	.40	.0703	.0000	.0086	2.4	.0163

Odor of the first sample, decided; of the others, none.—— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No. 12092. Fungi, *Crenothrix*, 1.
No organisms were found in the other samples.

Chemical Examination of Water from the Distributing Reservoir of the Ayer Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
12064	Apr. 17	V. slight.	Slight.	0.0	5.30	1.10	.0012	.0076	.0050	.0026	.45	.0350	.0004	.0452	2.1

Iron, .0000. Odor, none.—— The sample was collected from the reservoir.

Microscopical Examination.

Diatomaceæ, *Synedra*, 140. Algæ, *Protococcus*, 300. Infusoria, *Dynobryon cases*, 60. Total, 500.

BARRE.

The advice of the State Board of Health to the Barre Water Company with reference to taking the water of certain springs and brooks in that town as a public water supply may be found on pages 8 and 9 of this volume. Analyses of samples of water collected from these brooks are given on the following page.

BARRE.

Chemical Examination of Water from Brooks in Barre.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved	Sus-pended.					
	1894.														
12036	Apr. 12	Slight, clayey.	Cons.	0.18	2.60	0.90	.0000	.0074	.0062	.0012	.20	.0000	.0000	.2528	0.5
12035	Apr. 12	None.	V. slight.	0.18	2.45	1.20	.0000	.0090	.0082	.0008	.17	.0000	.0000	.2947	0.5

Odor of the first sample, very faintly vegetable; of the second, none, becoming vegetable on heating. —— The first sample was collected from a small brook about half a mile east of Allen Hill and about one and a quarter miles north-west of the centre of the village of Barre. It was proposed to construct a storage reservoir on this brook. The second sample was collected from a small tributary of Prince River, about one and a half miles north of the centre of the village of Barre. It was proposed to divert the water of this brook into the reservoir mentioned above.

Microscopical Examination.

No. 12036. Diatomaceæ, *Melosira*, 11; *Stauroneis*, 1; *Tabellaria*, 1. Fungi, *Crenothrix*, 2. Total, 15.
No. 12035. Diatomaceæ, *Diatoma*, 1; *Meridion*, 1. Fungi, *Crenothrix*, 1. Total, 3.

BELCHERTOWN.

The advice of the State Board of Health to the town of Belchertown with reference to the introduction of a water supply from Jabish or Chambray brooks in Belchertown will be found on pages 9 and 10 of this volume. An analysis of a sample of water collected from Chambray Brook is given below. Analyses of water from Jabish Brook and from the Knight and Gold Reservoir of the city of Springfield upon this brook are given under Springfield.

Chemical Examination of Water from Chambray Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11785	Feb. 19	None.	Slight.	0.60	3.00	1.15	.0000	.0108	.0088	.0020	.15	.0030	.0000	.5560	0.3

Odor, faintly vegetable. —— The sample was collected from the brook, at the line between Belchertown and Enfield.

Microscopical Examination.

Diatomaceæ, *Synedra*, 2; *Tabellaria*, 1. Miscellaneous, *Zoöglœa*, 3. Total, 6.

Water Supply of Belmont.

(See *Watertown.*)

Water Supply of Beverly.

(See *Salem.*)

Blackstone.

The advice of the State Board of Health to the Blackstone Water Company relative to the introduction of a water supply into this town from sources in the towns of Uxbridge and Blackstone will be found on pages 10 and 11 of this volume. Analyses of samples of water collected in connection with the investigation are given in the following table: —

Chemical Examination of Water from Emerson Brook and the Lower Ironstone Reservoir in Uxbridge, and from Fox Brook in Blackstone.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11763	Feb. 14	None.	V. slight.	0.70	3.65	1.60	.0006	.0124	.0106	.0018	.21	.0000	.0000	.6160	0.6
11764	Feb. 14	None.	V. slight.	0.55	3.35	1.45	.0010	.0156	.0132	.0024	.22	.0030	.0000	.5488	0.5
11765	Feb. 14	None.	V. slight.	0.55	3.65	1.45	.0000	.0124	.0108	.0016	.28	.0000	.0000	.5624	0.5

Odor of all samples, distinctly vegetable and sweetish. —— The first sample was collected from a mill pond on Emerson Brook, at Shove's saw-mill, the second from the Lower Ironstone Reservoir near the dam, and the third from Fox Brook, just above the Blackstone River. Analyses of samples from other sources collected in 1893 in connection with this investigation, may be found on page 101 of the annual report for 1893.

Microscopical Examination.

The number of organisms per cubic centimeter found in each of these samples was as follows: No. 11763, 27; No. 11764, 8; No. 11765, 61, nearly all of which were Diatomaceæ.

Water Supply of Boston.

Reservoir No. 6, begun in 1890, was practically completed at the end of 1893, and the storage of water in it was begun on Jan. 10, 1894. On the 1st of July the water had risen to within 2.34 feet of high-water mark, and remained nearly at this height until September 7, when water was drawn from the reservoir for the supply of the city until November 30. The reservoir is situated on Indian Brook, a small tributary of the Sudbury River from the south, and is partly in Hopkinton and partly in Ashland. Its area at high water is 185 acres, its storage capacity 1,530,300,000 gallons and its average depth 25.4 feet.

The filling of this reservoir has been looked forward to with interest, because it is the second large storage reservoir to be thoroughly prepared for the reception of water by the removal of all of the soil, stumps and vegetable matter, the first one being Reservoir No. 4, which is about three miles distant in an easterly direction. These two reservoirs are much alike in capacity, depth, the relation of their capacity to the amount of water entering them and the manner in which they were prepared for the storage of water. Each reservoir has a large amount of swampy land upon its water-shed, amounting on that of Reservoir No. 4 to 10.2 per cent. of the land surface, and on Reservoir No. 6 to 11.4 per cent.; but their water-sheds differ decidedly in respect to the amount of population upon them, the water-shed of Reservoir No. 6 containing 388 persons per square mile of land surface, and that of Reservoir No. 4 only 109 persons. When Reservoir No. 4 was filled it was found that the water improved instead of deteriorating, which is contrary to the usual experience when reservoirs which have not had the soil removed from them are filled; and it was also found in the case of Reservoir No. 4 that the water which remains stagnant at the bottom during the summer did not contain products of decomposition or become offensive, as is usually the case with the bottom water of reservoirs and ponds. Reservoir No. 4 has stood the test of years, as the water in it has always been nearly free from the growths of minute organisms which infest many reservoirs, and the water has always improved by storage in it.

The water entering Reservoir No. 6 has more color and contains more organic matter than that entering No. 4, and is affected to a greater extent by the waste matters from the population upon the

BOSTON.

water-shed; and on these accounts it was questioned whether this water would not be more liable to contain growths of organisms and accumulations of products of decomposition near the bottom. Up to the present time the analyses show that there has been a very marked decrease in the amount of color and organic matter by storage, that there has been no large growth of organisms, and that during the period of summer stagnation there has been only a comparatively small accumulation of products of decomposition at the bottom of the reservoir.

Further examinations of the water of this reservoir will be of interest, and, should they give the same indications as the results during the past year, they will show very conclusively the value of removing the soil and vegetable matter from large reservoirs in which water is to be stored for domestic use.

Reference was made in the annual report for 1893 to the fact that the water supplied to the city of Boston had a higher color than in any previous year, and by reference to the table of averages by years on page 103 it will be observed that the color was somewhat higher in 1894 than in 1893. The reasons are similar to those given in the previous report, viz., that the color of the water of the streams was darker than usual, and, in addition, the increasing consumption of water in the city required the use of a larger proportion of the water of Sudbury River, which has a higher color than that of Lake Cochituate; moreover, the color of the water of Reservoir No. 3 has been unfavorably affected by work incidental to the construction of Dam No. 5.

The capacity of Mystic Lake has been more severely taxed during the past year than in any previous year, notwithstanding the fact that the year was not an extremely dry one, and that the Charlestown district of Boston was supplied with water from the Cochituate works for several months, beginning with September 12. On August 31 the surface of the water in the lake had fallen so low that it became necessary to use temporary pumps to raise the water into the aqueduct leading to the main pumps, and from this date the lake continued to lower until October 10, when the water was drawn 12.08 feet below high-water mark and about 5 feet below the level of low tide in Boston harbor. The upper Mystic Lake is separated from the lower Mystic Lake, which is a tidal basin, by a dam; and when the water in the upper lake was drawn so low, a sufficient

amount of salt water filtered through to increase the amount of chlorine in the water of the upper lake, as will be seen by the analyses on page 105. After the ice formed upon the lake, in the latter part of 1894, the water began to have a disagreeable odor, and early in 1895 the odor became extremely offensive, so that the water consumers found it necessary to obtain well or spring water for drinking.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Indian Brook at Head of Reservoir No. 6, Hopkinton.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11570	Jan. 1	None.	V. slight.	2.70	6.60	4.30	.0004	.0389	.0362	.0036	.32	.0000	.0000	2.1450	1.1
11689	Feb. 1	Distinct.	Slight.	2.30	5.95	3.35	.0026	.0232	.0194	.0038	.55	.0030	.0001	2.0540	1.7
11831	Mar. 1	Slight.	Slight.	2.30	5.30	2.70	.0062	.0262	.0244	.0018	.45	.0000	.0000	1.9200	1.3
11971	Apr. 2	V. slight.	V. slight.	1.25	4.10	2.00	.0002	.0196	.0184	.0012	.43	.0030	.0000	1.0934	0.8
12123	Apr. 30	V. slight.	Cons.	2.30	5.55	3.20	.0004	.0292	.0278	.0014	.40	.0000	.0000	1.6432	0.9
12296	June 4	Slight.	Slight.	3.00	5.90	3.60	.0004	.0334	.0312	.0022	.30	.0000	.0000	2.0636	1.1
12451	July 2	V. slight.	Slight.	3.00	7.05	3.95	.0010	.0450	.0422	.0028	.34	.0000	.0001	2.3947	2.1
12626	July 30	Slight.	Cons., brown.	2.50	7.05	3.30	.0016	.0370	.0338	.0032	.53	.0060	.0000	1.6247	1.9
12859	Sept. 4	Slight, green.	Slight, brown.	1.10	6.65	2.90	.0014	.0314	.0286	.0028	.60	.0000	.0001	.9702	1.8
13046	Oct. 1	Slight.	V. slight.	0.90	7.95	2.45	.0002	.0278	.0258	.0020	1.08	.0020	.0000	.9243	2.2
13236	Nov. 1	V. slight.	V. slight.	2.30	9.15	4.75	.0004	.0406	.0386	.0020	.83	.0030	.0000	2.2792	2.7
13412	Dec. 3	V. slight.	V. slight.	2.30	7.65	4.00	.0016	.0356	.0334	.0022	.63	.0050	.0000	2.2946	1.8
Av.	....	....	....	2.16	6.58	3.38	.0014	.0323	.0300	.0024	.54	.0018	.0000	1.7839	1.6

Odor, generally distinctly vegetable, sometimes mouldy or disagreeable. —— The samples were collected from the brook, at its entrance into Reservoir No. 6.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 70.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 6, Ashland, collected near the Surface.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11832	Mar. 1	Decided, clayey.	Cons.	1.20	5.05	2.00	.0048	.0208	.0192	.0016	.46	.0050	.0002	1.4800	1.3
11972	Apr. 2	V. slight.	Cons.	0.90	3.70	1.60	.0030	.0168	.0152	.0016	.36	.0080	.0002	.7238	0.9
12125	Apr. 30	Slight.	Slight.	0.90	4.10	1.55	.0002	.0156	.0138	.0018	.39	.0080	.0001	.7742	0.8
12295	June 4	Distinct.	Cons.	1.10	3.75	1.45	.0042	.0238	.0162	.0076	.36	.0030	.0001	.7238	1.1
12452	July 2	Distinct.	V. slight, green.	0.85	3.90	1.80	.0000	.0220	.0188	.0032	.39	.0000	.0001	.7315	1.1
12627	July 30	V. slight.	Slight, green.	0.75	4.00	1.25	.0004	.0170	.0154	.0016	.40	.0060	.0000	.7315	0.8
12860	Sept. 4	Slight, green.	Slight, brown.	0.65	3.50	1.65	.0002	.0190	.0172	.0018	.37	.0000	.0001	.5852	1.6
13047	Oct. 1	Slight.	Slight.	0.60	3.65	1.25	.0000	.0170	.0148	.0022	.40	.0020	.0000	.5688	1.1
13237	Nov. 1	Distinct.	Slight.	0.43	3.45	1.45	.0002	.0166	.0148	.0018	.39	.0030	.0000	.4735	1.6
13413	Dec. 3	V. slight.	V. Slight.	0.65	4.20	1.90	.0000	.0220	.0204	.0016	.44	.0050	.0000	.6737	1.6
Av.	....	....	....	0.79	3.93	1.59	.0013	.0191	.0166	.0025	.40	.0040	.0001	.7466	1.2

Odor, generally distinctly vegetable. —— The samples were collected from the reservoir, near the dam. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 6, Ashland, collected near the Surface.*

[Number of organisms per cubic centimeter.]

	1894. Mar.	Apr.	May.	June.	July.	July.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	3	2	5	3	31	5	2	2	3
Number of sample,	11832	11972	12125	12295	12452	12627	12860	13047	13237	13413
PLANTS.										
Diatomaceæ,	0	2	77	25	301	1	31	39	70	5
Diatoma,	0	0	0	4	0	1	10	2	9	0
Melosira,	0	0	0	2	292	0	0	0	0	0
Synedra,	0	1	56	19	9	0	21	28	40	1
Tabellaria,	0	1	21	0	0	0	0	9	21	4
Algæ,	0	0	30	0	0	0	9	0	8	0
Protococcus,	0	0	0	0	0	0	9	0	8	0
Tetraspora,	0	0	20	0	0	0	0	0	0	0
Zoöspores,	0	0	10	0	0	0	0	0	0	0

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 6, Ashland, collected near the Surface* — Concluded.

[Number of organisms per cubic centimeter.]

	1894. Mar.	Apr.	May	June.	July.	July.	Sept.	Oct.	Nov.	Dec.
ANIMALS.										
Rhizopoda. Difflugia,	0	0	0	0	0	0	2	1	4	0
Infusoria,	0	0	100	1	137	51	5	4	4	6
Dinobryon,	0	0	0	0	137	0	0	0	0	0
Dinobryon cases,	0	0	0	1	0	44	0	0	0	4
Peridinium,	0	0	0	0	0	6	5	3	3	2
Synura,	0	0	100	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	1	0	1	1	0
Vermes,	0	0	0	13	2	0	0	0	1	2
Anurea,	0	0	0	5	0	0	0	0	1	2
Rotifer,	0	0	0	8	2	0	0	0	0	0
Miscellaneous. Zoöglœa,	0	2	0	40	32	0	40	84	0	0
TOTAL,	0	4	207	79	472	52	87	128	87	13

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 6, Ashland, collected near the Bottom.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
12124	Apr. 30	V. slight.	Cons., green.	0.90	4.15	1.85	.0046	.0150	.0126	.0024	.39	.0070	.0001	.7876	0.6
12297	June 4	Distinct.	Cons., rusty.	0.90	4.20	2.10	.0038	.0204	.0174	.0030	.36	.0050	.0001	.7469	1.1
12453	July 2	Slight.	Slight.	0.80	4.00	1.80	.0074	.0150	.0132	.0018	.37	.0030	.0002	.6391	1.1
12628	July 30	Slight.	Slight, brown.	1.25	3.40	1.55	.0138	.0164	.0150	.0014	.38	.0000	.0023	.6653	1.3
12861	Sept. 4	Slight.	Slight.	2.60	5.25	1.75	.0336	.0184	.0164	.0020	.36	.0000	.0001	.8008	1.3
13048	Oct. 1	Distinct.	Cons.	0.50	3.75	1.60	.0016	.0186	.0150	.0036	.37	.0000	.0000	.5846	1.1
13238	Nov. 1	Slight.	Slight.	0.43	3.70	1.80	.0000	.0178	.0142	.0036	.39	.0030	.0000	.5005	1.4
13414	Dec. 3	V. slight.	V. slight.	0.68	4.20	1.40	.0006	.0186	.0152	.0034	.40	.0030	.0000	.6545	1.6
Av.	....	....	....	1.01	4.08	1.73	.0082	.0175	.0149	.0026	.38	.0026	.0004	.6724	1.2

Odor, generally vegetable; in September, decidedly disagreeable. —— The samples were collected from the reservoir, near the dam.

BOSTON.

Sudbury River Supply. — *Microscopical Examination of Water from Reservoir No. 6, Ashland, collected near the Bottom.*

[Number of organisms per cubic centimeter.]

	1894.							
	May.	June.	July.	July.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	5	3	31	5	2	2	3
Number of sample,	12124	12297	12453	12628	12861	13048	13238	13414
PLANTS.								
Diatomaceæ,	7	113	11	1	6	66	109	5
Asterionella,	0	0	0	0	6	0	0	0
Diatoma,	0	0	0	0	0	6	3	0
Melosira,	0	0	6	0	0	0	44	1
Synedra,	3	108	5	1	0	44	13	1
Tabellaria,	4	5	0	0	0	16	49	3
Fungi. Crenothrix,	0	56	33	248	3	2	0	0
ANIMALS.								
Rhizopoda. Difflugia,	0	0	0	0	0	7	3	3
Infusoria,	2	1	5	69	0	3	4	1
Dinobryon cases,	1	0	0	68	0	0	0	0
Mallomonas,	1	0	0	0	0	0	0	0
Peridinium,	0	1	4	1	0	0	4	1
Trachelomonas,	0	0	1	0	0	3	0	0
Vermes. Anurea,	0	1	1	0	0	0	0	0
Miscellaneous,	0	84	40	152	104	228	0	0
Acarina,	0	0	.04	0	0	0	0	0
Zoöglœa,	0	84	40	152	104	228	0	0
Total,	9	255	90	470	113	306	116	9

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Cold Spring Brook, at Head of Reservoir No. 4, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11572	Jan. 1	None.	V. slight.	1.40	5.30	2.55	.0004	.0242	.0198	.0044	.34	.0130	.0000	1.2480	1.3
11690	Feb. 1	V. slight.	Slight, sandy.	1.10	4.50	2.35	.0000	.0152	.0128	.0024	.33	.0070	.0000	1.5405	1.3
11821	Mar. 1	V. slight.	Slight.	1.45	5.05	2.30	.0008	.0238	.0226	.0012	.30	.0070	.0000	1.2144	1.4
11973	Apr. 2	V. slight.	Slight.	1.40	3.65	1.75	.0000	.0202	.0178	.0024	.28	.0030	.0000	.8917	0.6
12130	May 1	V. slight.	V. slight.	2.10	4.20	2.50	.0010	.0256	.0242	.0014	.30	.0030	.0000	1.2760	0.9
12298	June 4	V. slight.	V. slight.	2.70	5.90	3.55	.0006	.0328	.0304	.0024	.21	.0030	.0001	1.7864	1.6
12454	July 2	None.	V. slight.	1.90	5.25	3.00	.0010	.0278	.0258	.0020	.31	.0000	.0001	1.3706	1.3
12643	Aug. 1	V. slight.	V. slight.	0.75	4.50	2.00	.0000	.0208	.0176	.0032	.30	.0020	.0001	.6406	1.1
12862	Sept. 4	Distinct.	Slight.	0.65	3.30	1.45	.0028	.0186	.0166	.0020	.22	.0020	.0001	.5390	0.9
13062	Oct. 2	V. slight.	V. slight.	0.40	3.70	1.10	.0000	.0100	.0084	.0016	.36	.0000	.0001	.3476	0.9
13239	Nov. 1	V. slight	Slight.	1.80	7.75	3.60	.0004	.0362	.0342	.0020	.43	.0080	.0000	1.8865	1.9
13415	Dec. 3	V. slight.	V. slight.	1.60	6.15	2.85	.0008	.0288	.0268	.0020	.39	.0030	.0000	1.6016	1.7
Av.	....	....	....	1.44	4.94	2.42	.0007	.0237	.0214	.0023	.31	.0043	.0000	1.1952	1.2

Averages by Years.

-	1889*	-	-	2.24	-	-	.0025	.0410	.0385	.0025	.28	.0056	.0001	-	-
-	1890	-	-	0.91	4.49	2.01	.0011	.0243	.0210	.0033	.24	.0090	.0001	-	1.5
-	1891	-	-	1.30	4.87	2.30	.0009	.0297	.0262	.0035	.23	.0087	.0001	-	1.3
-	1892	-	-	1.44	5.15	2.57	.0003	.0308	.0266	.0042	.25	.0068	.0001	-	1.2
-	1893	-	-	1.23	4.52	2.16	.0013	.0248	.0212	.0036	.26	.0031	.0001	.9765	1.3
-	1894	-	-	1.44	4.94	2.42	.0007	.0237	.0214	.0023	.31	.0043	.0000	1.1952	1.2

* June to December.

NOTE to analyses of 1894: Odor, distinctly vegetable. —— The samples were collected from the brook, at its entrance into Reservoir No. 4.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 52.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 4, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11573	Jan. 1	Slight.	Slight.	1.00	4.85	1.90	.0104	.0214	.0188	.0026	.30	.0100	.0001	.9344	1.1
11691	Feb. 1	Slight.	Slight.	1.10	4.45	2.20	.0062	.0178	.0152	.0026	.32	.0120	.0000	.9322	1.3
11822	Mar. 1	Distinct.	Slight.	0.73	4.00	1.45	.0078	.0206	.0176	.0030	.36	.0070	.0002	.7280	1.3
11974	Apr. 2	V. slight.	Slight.	1.00	3.80	1.70	.0028	.0238	.0212	.0026	.26	.0070	.0001	.7677	0.8
12131	May 1	Slight.	Slight.	1.00	3.60	1.75	.0000	.0170	.0158	.0012	.28	.0050	.0001	.8416	0.8
12299	June 4	Slight.	Slight.	1.00	4.25	2.00	.0024	.0212	.0198	.0014	.26	.0050	.0000	.7969	1.1
12455	July 2	Slight.	Slight.	0.90	3.55	1.50	.0004	.0186	.0172	.0014	.29	.0000	.0000	.9009	1.3
12644	Aug. 1	Slight.	Slight.	0.78	4.35	1.90	.0000	.0230	.0210	.0020	.28	.0000	.0001	.7315	0.8
12863	Sept. 4	Slight.	Slight.	0.70	3.40	1.35	.0004	.0188	.0152	.0036	.27	.0020	.0001	.5698	0.9
13063	Oct. 2	Distinct.	Slight.	0.55	3.65	1.50	.0004	.0168	.0154	.0014	.31	.0000	.0000	.5688	1.1
13240	Nov. 1	Distinct, clayey.	Cons., earthy.	0.45	3.50	1.55	.0002	.0196	.0180	.0016	.28	.0030	.0000	.4966	1.3
13416	Dec. 3	Slight.	V. slight.	0.75	4.60	2.00	.0010	.0240	.0208	.0032	.31	.0030	.0000	1.1396	1.8
Av.	....	....	....	0.83	4.00	1.73	.0027	.0202	.0180	.0022	.29	.0045	.0001	.7840	1.1

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
–	1887*	–	–	0.74	3.71	1.51	.0005	.0246	–	–	.25	.0033	–	–	–
–	1888	–	–	0.72	3.83	1.70	.0007	.0277	–	–	.22	.0054	.0001	–	–
–	1889	–	–	0.85	3.48	1.98	.0016	.0251	.0218	.0033	.23	.0068	.0002	–	–
–	1890	–	–	0.61	3.67	1.40	.0008	.0222	.0191	.0031	.24	.0096	.0001	–	1.7
–	1891	–	–	0.53	3.24	1.55	.0006	.0187	.0156	.0031	.20	.0062	.0001	–	0.9
–	1892	–	–	0.64	3.60	1.52	.0002	.0200	.0168	.0032	.23	.0061	.0001	–	1.1
–	1893	–	–	0.77	3.54	1.63	.0024	.0206	.0178	.0033	.23	.0048	.0001	.6773	1.0
–	1894	–	–	0.83	4.00	1.73	.0027	.0202	.0180	.0022	.29	.0045	.0001	.7840	1.1

* June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable, sometimes none. —— The samples were collected from the reservoir, near the gate-house, 1 foot beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 4, Ashland.*

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	2	2	3	2	5	3	2	5	3	2	3
Number of sample,	11573	11691	11822	11974	12131	12299	12455	12644	12863	13063	13240	13416
PLANTS.												
Diatomaceæ,	1	0	pr.	3	52	0	1	90	6	13	15	4
Cyclotella,	0	0	0	pr.	2	0	1	36	3	9	8	2
Synedra,	1	0	pr.	2	42	0	0	48	3	1	5	2
Tabellaria,	0	0	0	1	8	0	0	6	0	3	2	0
Algæ,	0	0	0	2	0	91	225	14	49	20	8	0
Botrycoccus,	0	0	0	0	0	55	0	0	0	0	0	0
Chlorococcus,	0	0	0	2	0	1	203	0	0	0	0	0
Protococcus,	0	0	0	0	0	35	0	0	30	4	0	0
Raphidium,	0	0	0	0	0	0	5	14	19	16	8	0
Scenedesmus,	0	0	0	0	0	0	17	0	0	0	0	0
Fungi. Crenothrix,	0	0	0	2	1	1	0	6	0	0	0	0
ANIMALS.												
Infusoria,	4	29	2	1	2	5	8	1	3	2	0	0
Ciliated infusorian,	0	0	0	0	0	5	0	0	0	0	0	0
Dinobryon,	0	19	2	0	0	0	0	0	0	0	0	0
Dinobryon cases,	0	10	0	0	0	0	0	0	0	0	0	0
Mallomonas,	0	0	0	0	0	0	0	0	3	1	0	0
Monas,	0	0	0	0	0	0	8	0	0	0	0	0
Peridinium,	4	10	pr.	0	0	0	0	1	0	0	0	0
Trachelomonas,	0	0	0	1	2	0	0	0	0	1	0	0
Vermes. Polyarthra,	0	0	3	pr.	1	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	0	8	pr.	0	10	0	8	36	55	30	0	0
TOTAL,	5	42	5	8	66	97	242	147	126	65	23	4

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Sudbury River, at Head of Reservoir No. 2, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11574	Jan. 1	V. slight.	Cons.	1.40	5.55	2.45	.0018	.0216	.0194	.0022	.38	.0080	.0000	1.2324	1.4
11692	Feb. 1	V. slight.	Slight.	1.00	4.80	1.80	.0000	.0166	.0148	.0018	.39	.0120	.0000	.8769	1.3
11823	Mar. 1	V. slight.	Slight.	1.30	5.15	2.00	.0002	.0230	.0206	.0024	.35	.0120	.0000	1.1200	1.3
11975	April 2	V. slight.	Cons.	1.20	3.60	1.45	.0000	.0212	.0192	.0020	.31	.0050	.0002	.8470	0.8
12132	May 1	Slight.	Slight.	2.00	4.20	2.45	.0004	.0256	.0240	.0016	.35	.0050	.0000	1.1640	0.9
12300	June 4	Slight.	Slight.	1.90	5.30	3.05	.0030	.0298	.0262	.0036	.26	.0070	.0000	1.4245	1.3
12456	July 2	Slight.	Slight.	1.50	4.45	2.40	.0002	.0258	.0244	.0014	.25	.0030	.0001	1.0125	1.3
12645	Aug. 1	Slight.	Slight.	1.00	4.10	1.75	.0008	.0248	.0236	.0012	.29	.0030	.0001	.8701	0.7
12864	Sept. 4	Slight.	Slight.	0.90	4.35	1.90	.0016	.0220	.0200	.0020	.25	.0080	.0002	.7122	1.3
13064	Oct. 2	V. slight.	Cons.	0.78	4.10	1.85	.0000	.0202	.0176	.0026	.40	.0000	.0000	.8058	0.8
13241	Nov. 1	Slight.	Slight, earthy.	1.30	5.10	2.50	.0002	.0244	.0228	.0016	.43	.0030	.0000	1.2281	1.4
13417	Dec. 3	Slight.	Slight.	1.40	5.40	2.40	.0004	.0224	.0200	.0024	.40	.0050	.0000	1.3860	1.4
Av.	....	....	....	1.31	4.68	2.17	.0007	.0231	.0211	.0020	.34	.0059	.0001	1.0566	1.2

Averages by Years.

–	1887*	–	–	1.13	5.37	1.81	.0021	.0313	–	–	.39	.0170	–	–	–
–	1888	–	–	1.19	4.76	2.07	.0018	.0293	–	–	.29	.0108	.0002	–	–
–	1889	–	–	1.25	3.62	1.38	.0013	.0294	.0267	.0027	.30	.0080	.0002	–	–
–	1890	–	–	0.82	5.18	2.09	.0014	.0256	.0220	.0036	.30	.0135	.0001	–	1.7
–	1891	–	–	0.88	4.35	1.81	.0008	.0274	.0236	.0038	.26	.0112	.0001	–	1.1
–	1892	–	–	1.00	4.71	2.08	.0006	.0247	.0214	.0033	.28	.0099	.0001	–	1.3
–	1893	–	–	0.99	4.57	2.03	.0019	.0232	.0196	.0036	.34	.0068	.0001	.8219	1.4
–	1894	–	–	1.31	4.68	2.17	.0007	.0231	.0211	.0020	.34	.0059	.0001	1.0566	1.2

* June to December.

NOTE to analyses of 1894: Odor, distinctly vegetable, sometimes also faintly mouldy. —— The samples were collected from the river, near the old dam at the upper end of Reservoir No. 2, at a depth of 1 foot beneath the surface.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 96.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 2, Framingham.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11575	Jan. 1	V. slight.	Slight.	1.20	5.10	2.25	.0014	.0214	.0186	.0028	.39	.0120	.0001	1.1154	2.1
11693	Feb. 1	Slight.	Slight.	1.00	4.45	1.90	.0000	.0168	.0144	.0024	.36	.0150	.0000	.9045	1.3
11824	Mar. 1	Slight.	Slight.	0.83	4.05	1.85	.0006	.0176	.0160	.0016	.32	.0070	.0000	.8400	1.3
11976	Apr. 2	V. slight.	Slight.	1.20	3.70	1.85	.0006	.0210	.0184	.0026	.28	.0070	.0000	.7892	0.8
12133	May 1	Slight.	Slight.	1.20	3.70	1.90	.0000	.0198	.0176	.0022	.31	.0050	.0000	.9040	0.8
12301	June 4	Slight.	Slight.	1.50	4.90	2.60	.0030	.0234	.0218	.0016	.30	.0080	.0000	1.0125	1.1
12457	July 2	Distinct.	Slight.	1.20	4.40	2.40	.0006	.0254	.0216	.0038	.27	.0030	.0001	1.0087	1.3
12646	Aug. 1	Distinct.	Slight.	0.85	4.40	2.10	.0000	.0220	.0196	.0024	.29	.0020	.0000	.7276	0.7
12865	Sept. 4	Distinct.	Slight.	1.20	3.85	1.85	.0004	.0254	.0214	.0040	.26	.0020	.0001	.7392	1.3
13065	Oct. 2	Slight.	Cons.	1.00	4.40	2.25	.0000	.0208	.0186	.0022	.36	.0000	.0000	.7742	0.9
13242	Nov. 1	Slight.	Slight, earthy.	0.90	4.00	1.35	.0016	.0224	.0206	.0018	.37	.0030	.0000	.8431	1.3
13418	Dec. 3	Slight.	Slight.	1.35	5.40	2.30	.0010	.0236	.0224	.0012	.42	.0050	.0000	1.4630	2.3
Av.	....	....	....	1.12	4.36	2.05	.0008	.0216	.0193	.0023	.33	.0058	.0000	.9268	1.3

Averages by Years.

-	1887*	-	-	1.09	4.94	1.87	.0015	.0335	-	-	.34	.0048	-	-	-
-	1888	-	-	1.08	4.63	2.01	.0005	.0300	-	-	.30	.0102	.0001	-	-
-	1889	-	-	1.04	3.42	1.26	.0015	.0296	.0252	.0044	.29	.0075	.0002	-	-
-	1890	-	-	0.77	4.58	1.83	.0010	.0235	.0191	.0044	.28	.0128	.0001	-	1.7
-	1891	-	-	0.72	4.02	1.68	.0004	.0230	.0194	.0036	.24	.0105	.0001	-	1.0
-	1892	-	-	0.89	4.35	1.92	.0004	.0231	.0192	.0039	.29	.0082	.0001	-	1.3
-	1893	-	-	0.98	4.28	1.86	.0010	.0219	.0190	.0029	.31	.0054	.0001	.8120	1.2
-	1894	-	-	1.12	4.36	2.05	.0008	.0216	.0193	.0023	.33	.0058	.0000	.9268	1.3

* June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable. —— The samples were collected from the reservoir, near the gate-house, at a depth of 8 feet beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY.—*Microscopical Examination of Water from Reservoir No. 2, Framingham.*

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	2	2	4	3	5	3	2	5	3	2	3
Number of sample,	11575	11693	11824	11976	12133	12301	12457	12646	12865	13065	13242	13418
PLANTS.												
Diatomaceæ,	6	5	7	48	54	13	82	57	91	88	164	10
Cyclotella,	0	0	0	2	1	0	0	0	80	3	1	0
Diatoma,	1	0	0	1	0	0	0	5	6	5	32	0
Melosira,	0	0	1	8	0	0	5	0	0	2	12	0
Meridion,	0	2	0	3	1	0	0	0	0	0	0	0
Navicula,	1	pr.	0	3	0	0	0	0	0	1	1	0
Synedra,	4	3	5	22	40	11	76	52	5	76	116	6
Tabellaria,	pr.	pr.	1	9	12	2	1	0	0	1	2	4
Cyanophyceæ,	0	0	0	0	0	0	6	11	0	0	4	0
Anabæna,	0	0	0	0	0	0	0	11	0	0	4	0
Merismopedia,	0	0	0	0	0	0	6	0	0	0	0	0
Algæ,	0	0	0	pr.	1	4	210	80	60	62	4	0
Chlorococcus,	0	0	0	0	0	4	192	1	0	2	0	0
Protococcus,	0	0	0	0	0	0	0	58	24	30	0	0
Raphidium,	0	0	0	0	0	0	3	8	28	22	4	0
Scenedesmus,	0	0	0	pr.	1	0	15	6	0	0	0	0
Staurogenia,	0	0	0	0	0	0	0	0	0	8	0	0
Ulothrix,	0	0	0	0	0	0	0	7	8	0	0	0
Fungi. Crenothrix,	4	4	2	2	0	0	0	2	0	4	13	0
ANIMALS.												
Rhizopoda. Difflugia,	0	0	0	0	0	0	0	0	0	0	5	0
Infusoria,	1	0	1	1	1	0	8	0	0	3	0	0
Euglena,	0	0	0	1	1	0	0	0	0	0	0	0
Monas,	1	0	0	0	0	0	4	0	0	0	0	0
Peridinium,	0	0	1	0	0	0	4	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	0	0	3	0	0
Vermes. Rotatorian ova,	0	0	0	1	2	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	0	2	1	2	44	25	98	104	68	176	124	0
TOTAL,	11	11	11	54	102	42	402	254	219	333	314	10

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Walker's Brook Marlborough.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11571	Jan. 1	Distinct.	Cons.	0.45	15.10	4.20	.0128	.0168	.0150	.0018	2.34	.3250	.0012	.4976	5.8
11687	Feb. 1	Distinct.	Cons., earthy.	0.20	14.40	4.05	.0312	.0116	.0100	.0016	2.19	.2000	.0014	.3286	5.0
11818	Mar. 1	Distinct, milky.	Slight.	0.55	15.20	3.85	.1440	.0264	.0238	.0026	2.59	.2000	.0018	.6640	5.1
11969	Apr. 2	V. slight.	Slight.	0.50	13.30	3.45	.0336	.0180	.0158	.0022	2.18	.2750	.0030	.4520	4.6
12127	May 1	Distinct.	Cons., fibrous.	0.50	13.45	4.30	.0024	.0210	.0162	.0048	2.20	.2000	.0028	.4944	4.6
12310	June 5	Slight.	Slight.	0.65	14.95	3.85	.0016	.0218	.0204	.0014	2.35	.2750	.0011	.5251	5.4
12467	July 5	Slight.	Slight.	0.20	13.05	2.70	.0018	.0176	.0148	.0028	1.86	.1350	.0020	.2087	4.9
12641	Aug. 1	Distinct, milky.	Slight.	0.30	15.00	3.50	.0000	.0172	.0154	.0018	1.94	.0500	.0008	.3095	5.1
12853	Sept. 4	Slight.	Slight.	0.17	10.65	1.90	.0016	.0106	.0074	.0032	1.49	.1000	.0004	.2156	3.8
13052	Oct. 1	V. slight.	Slight.	0.15	12.25	2.85	.0000	.0132	.0118	.0014	1.78	.1750	.0007	.1935	4.4
13252	Nov. 1	Thick.	Heavy, earthy.	1.40	18.20	5.10	.0238	.0686	.0400	.0286	2.10	.1300	.0025	1.3898	5.6
13423	Dec. 3	Slight.	Cons.	0.42	14.15	3.65	.1920	.0180	.0150	.0030	1.97	.2000	.0036	.3619	5.0
Av.	....	....	....	0.46	14.14	3.62	.0371	.0217	.0171	.0046	2.08	.1888	.0018	.4701	4.9

Averages by Years.

-	1892	-	-	0.49	16.84	4.35	.0307	.0274	.0225	.0048	2.58	.2975	.0037	-	5.7
-	1893	-	-	0.38	14.05	3.94	.0337	.0257	.0180	.0077	1.96	.1878	.0020	.3927	5.2
-	1894	-	-	0.46	14.14	3.62	.0371	.0217	.0171	.0046	2.08	.1888	.0018	.4701	4.9

Odor, generally distinctly vegetable and musty, becoming stronger on heating. —— The samples were collected from the brook, at the first road bridge below Maple Street, about a mile south of the centre of the city of Marlborough. This series of analyses is being made in order to determine to what extent the pollution of the brook will be diminished by the introduction of a sewerage system into the city of Marlborough. The system was put in operation in the latter part of 1891.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Stony Brook, at Head of Reservoir No. 3, Southborough.**

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11576	Jan. 1	V. slight.	V. slight.	1.00	7.15	2.55	.0016	.0228	.0206	.0022	.48	.0410	.0003	1.0280	2.2
11694	Feb. 1	Slight.	V. slight.	1.00	6.00	2.40	.0002	.0192	.0160	.0032	.50	.0300	.0001	.9164	1.9
11825	Mar. 1	Slight.	Slight.	1.10	6.00	2.25	.0012	.0204	.0184	.0020	.45	.0230	.0001	.9480	1.8
11977	Apr. 2	V. slight.	Slight.	1.23	4.85	2.20	.0008	.0242	.0218	.0024	.40	.0170	.0002	.8893	1.6
12134	May 1	Slight.	V. slight.	2.00	5.20	2.75	.0012	.0262	.0246	.0016	.42	.0070	.0001	1.2096	1.7
12302	June 4	Distinct.	Cons.	1.90	5.70	2.80	.0014	.0376	.0350	.0026	.32	.0080	.0001	1.3729	1.6
12458	July 2	Distinct.	Slight, brown.	1.50	7.50	3.40	.0030	.0468	.0230	.0238	.36	.0000	.0000	1.4029	2.7
12647	Aug. 1	Decided, green.	Cons., rusty.	1.20	7.15	2.45	.0002	.0422	.0276	.0146	.58	.0070	.0000	.9394	2.2
12866	Sept. 4	Distinct.	Slight, rusty.	1.50	6.35	2.85	.0024	.0450	.0396	.0054	.58	.0020	.0001	.9548	1.8
13066	Oct. 2	Slight.	Slight.	0.95	6.70	2.65	.0036	.0278	.0270	.0008	.63	.0000	.0001	.8295	2.1
13243	Nov. 1	Distinct, clayey.	Slight, earthy.	1.40	7.85	3.10	.0026	.0334	.0308	.0026	.63	.0080	.0001	1.1627	2.5
13419	Dec. 3	Slight.	Cons.	1.00	6.45	2.25	.0094	.0170	.0146	.0024	.54	.0380	.0005	.9856	2.2
Av.	....	....	....	1.32	6.41	2.64	.0023	.0302	.0249	.0053	.49	.0151	.0001	1.0533	2.0

Averages by Years.

-	1887†	-	-	0.97	7.74	2.36	.0029	.0355	-	-	.74	.0152	-	-	-
-	1888	-	-	1.16	6.25	2.17	.0039	.0312	-	-	.51	.0303	.0004	-	-
-	1889	-	-	1.11	5.04	1.76	.0061	.0308	.0280	.0028	.50	.0275	.0005	-	-
-	1890	-	-	0.72	7.31	2.12	.0033	.0257	.0225	.0032	.56	.0262	.0003	-	2.4
-	1891	-	-	0.86	6.15	2.24	.0047	.0291	.0256	.0035	.59	.0226	.0003	-	2.0
-	1892	-	-	0.96	6.19	2.35	.0015	.0291	.0252	.0039	.49	.0202	.0002	-	1.9
-	1893	-	-	0.95	6.03	2.27	.0027	.0273	.0237	.0036	.50	.0127	.0002	.8254	2.0
-	1894	-	-	1.32	6.41	2.64	.0023	.0302	.0249	.0053	.49	.0151	.0001	1.0533	2.0

* The quality of the water in Stony Brook at the upper end of Reservoir No. 3 and in the reservoir itself has been unfavorably affected during much of this year by the construction of a dam for another reservoir further up the brook, which has made it necessary to flood the swamps above from time to time, and subsequently to allow the water to flow down the brook.

† June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable, frequently mouldy or unpleasant; on heating, the odor is stronger and frequently grassy. —— The samples were collected from the brook, about 50 feet below the first road above Reservoir No. 3, at a depth of 1 foot beneath the surface.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 500. The greatest numbers found were 3,210 in August, consisting chiefly of Diatomaceæ (*Melosira*) and Zoöglœa, and 1,164 in September, chiefly Diatomaceæ (*Melosira*), Crenothrix and Zoöglœa.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 3, Framingham.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11577	Jan. 1	V. slight.	Slight.	0.90	6.95	2.35	.0024	.0266	.0238	.0028	.53	.0250	.0003	.8954	2.2
11695	Feb. 1	V. slight.	V. slight.	0.90	6.75	2.80	.0016	.0186	.0172	.0014	.47	.0300	.0002	.9385	1.9
11826	Mar. 1	Distinct.	Slight.	0.78	5.70	1.90	.0038	.0192	.0174	.0018	.47	.0200	.0002	.8176	1.8
11978	Apr. 2	Slight.	Slight.	0.90	4.35	1.95	.0008	.0210	.0188	.0022	.35	.0150	.0002	.7446	1.3
12135	May 1	Slight.	Cons.	1.10	4.25	1.70	.0010	.0204	.0186	.0018	.43	.0100	.0002	.8056	1.3
12303	June 4	Decided, green.	Cons., brown.	1.25	5.35	2.45	.0010	.0336	.0270	.0066	.36	.0100	.0001	.9332	1.6
12459	July 2	Distinct.	Slight.	1.30	5.30	2.50	.0018	.0296	.0260	.0036	.32	.0050	.0002	1.0395	2.2
12648	Aug. 1	Slight, green.	Slight, green.	0.95	5.30	2.10	.0006	.0276	.0250	.0026	.39	.0020	.0001	.8932	2.3
12867	Sept. 4	Distinct.	Slight, brown.	0.85	5.25	2.10	.0040	.0308	.0272	.0036	.37	.0020	.0002	.7161	1.8
13067	Oct. 2	Distinct.	Cons.	0.90	5.40	2.00	.0018	.0330	.0260	.0070	.42	.0000	.0000	.8453	1.8
13244	Nov. 1	Distinct.	Cons., green.	0.70	5.20	2.15	.0020	.0300	.0248	.0052	.38	.0000	.0000	.7854	2.1
13420	Dec. 3	Slight.	Cons., green.	1.05	6.00	2.40	.0012	.0280	.0256	.0024	.48	.0070	.0001	1.0164	2.1
Av.	....	....	....	0.97	5.48	2.20	.0018	.0265	.0231	.0034	.41	.0105	.0002	.8692	1.9

Averages by Years.

-	1887*	-	-	0.91	5.48	2.02	.0073	.0318	-	-	.43	.0170	-	-	-
-	1888	-	-	0.98	4.98	1.79	.0038	.0288	-	-	.40	.0218	.0003	-	-
-	1889	-	-	0.84	4.39	1.50	.0042	.0306	.0254	.0052	.42	.0182	.0003	-	-
-	1890	-	-	0.62	5.40	1.84	.0020	.0238	.0197	.0041	.40	.0229	.0002	-	2.0
-	1891	-	-	0.60	4.75	1.66	.0032	.0242	.0200	.0042	.38	.0190	.0002	-	1.7
-	1892	-	-	0.72	5.17	1.97	.0024	.0254	.0219	.0035	.40	.0211	.0001	-	1.8
-	1893	-	-	0.90	4.97	2.10	.0028	.0259	.0207	.0052	.37	.0100	.0001	.7681	1.7
-	1894	-	-	0.97	5.48	2.20	.0018	.0265	.0231	.0034	.41	.0105	.0002	.8692	1.9

* June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable, frequently mouldy or unpleasant. —— The samples were collected from the reservoir, near the gate-house, at a depth of 8 feet beneath the surface. For monthly record of height of water in this reservoir, see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 3, Framingham.*

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	2	2	4	3	5	3	2	5	3	2	5
Number of sample,	11577	11695	11826	11978	12135	12303	12459	12648	12867	13067	13244	13420
PLANTS.												
Diatomaceæ,	**3**	**pr.**	**2**	**135**	**147**	**17**	**25**	**11**	**1**	**16**	**1,264**	**422**
Asterionella,	0	0	2	0	59	0	0	0	0	9	940	240
Cyclotella,	0	0	0	1	0	3	0	0	0	2	132	24
Diatoma,	0	0	0	2	0	10	0	0	1	2	28	0
Melosira,	0	0	0	5	2	0	22	10	0	0	0	2
Synedra,	2	pr.	pr.	104	34	1	2	1	0	2	76	0
Tabellaria,	1	0	pr.	23	52	3	1	0	0	1	88	156
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**23**	**15**	**23**	**12**	**0**
Anabæna,	0	0	0	0	0	4	0	0	0	11	1	0
Chroöcoccus,	0	0	0	0	0	0	0	10	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	0	11	9	9	2	0
Merismopedia,	0	0	0	0	0	0	0	0	0	0	8	0
Microcystis,	0	0	0	0	0	0	0	2	6	3	1	0
Algæ,	**0**	**0**	**0**	**0**	**2**	**22**	**93**	**808**	**172**	**22**	**42**	**6**
Chlorococcus,	0	0	0	0	0	10	93	0	0	0	0	0
Protococcus,	0	0	0	0	0	10	0	800	172	6	14	0
Raphidium,	0	0	0	0	2	2	0	8	0	16	12	0
Staurogenia,	0	0	0	0	0	0	0	0	0	0	8	6
Tetraspora,	0	0	0	0	0	0	0	0	0	0	8	0
ANIMALS.												
Infusoria,	**40**	**2**	**5**	**5**	**10**	**1**	**3**	**5**	**8**	**1**	**9**	**0**
Chlamydomonas,	40	0	0	0	0	0	0	0	0	0	0	0
Dinobryon cases,	0	0	5	0	10	0	0	0	0	0	0	0
Euglena,	pr.	0	0	5	0	0	0	0	0	0	0	0
Mallomonas,	0	0	0	pr.	0	0	0	2	0	0	8	0
Peridinium,	pr.	0	pr.	0	0	1	1	1	0	1	0	0
Syncrypta,	0	2	0	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	pr.	0	0	2	2	8	0	1	0
Vermes,	**0**	**pr.**	**0**	**0**	**2**	**0**	**0**	**2**	**0**	**0**	**0**	**0**
Polyarthra,	0	pr.	0	0	1	0	0	0	0	0	0	0
Rotifer,	0	0	0	0	1	0	0	2	0	0	0	0
Miscellaneous. Zoöglœa,	**0**	**0**	**0**	**6**	**68**	**0**	**24**	**0**	**0**	**17**	**0**	**0**
TOTAL,	43	2	7	146	229	44	145	849	191	79	1,327	428

BOSTON.

COCHITUATE SUPPLY.— *Chemical Examination of Water from Lake Cochituate, in Wayland.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11578	Jan. 1	V. slight.	Cons.	0.10	4.50	1.50	.0016	.0138	.0108	.0030	.49	.0075	.0002	.3572	1.9
11696	Feb. 1	Slight.	Slight, white.	0.20	4.80	1.60	.0016	.0134	.0112	.0022	.53	.0120	.0000	.4013	1.9
11827	Mar. 1	Slight.	Slight.	0.23	5.00	1.35	.0000	.0148	.0130	.0018	.51	.0100	.0000	.4040	2.1
11979	Apr. 2	Slight.	Cons., green.	0.23	4.80	1.45	.0006	.0184	.0152	.0032	.50	.0120	.0001	.3296	1.9
12138	May 1	Slight.	Cons.	0.23	4.50	2.00	.0006	.0174	.0138	.0036	.53	.0080	.0001	.3888	2.1
12304	June 4	Distinct.	Slight, green.	0.30	4.55	1.50	.0008	.0182	.0156	.0026	.47	.0150	.0001	.3942	1.8
12460	July 2	Distinct.	Slight.	0.20	4.80	1.95	.0000	.0180	.0152	.0028	.54	.0050	.0003	.4081	2.3
12649	Aug. 1	Slight.	V. slight.	0.18	5.00	1.50	.0006	.0162	.0136	.0026	.51	.0060	.0003	.4004	2.4
12868	Sept. 4	Slight, green.	Slight.	0.15	4.70	1.35	.0016	.0172	.0134	.0038	.50	.0000	.0001	.3157	1.8
13068	Oct. 2	V. slight.	Cons.	0.15	5.80	2.50	.0000	.0148	.0132	.0016	.56	.0020	.0000	.3871	2.1
13245	Nov. 1	Distinct.	Slight.	0.18	5.00	1.25	.0008	.0160	.0136	.0024	.48	.0030	.0000	.3311	2.1
13422	Dec. 3	Distinct.	Cons., green.	0.23	3.70	1.15	.0012	.0174	.0154	.0020	.50	.0030	.0000	.3211	2.2
Av.	....	....	....	0.20	4.76	1.59	.0008	.0163	.0137	.0026	.51	.0070	.0001	.3699	2.1

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
-	1887*	-	-	0.21	5.08	1.38	.0017	.0186	-	-	.44	.0096	-	-	-
-	1888	-	-	0.19	4.90	1.24	.0033	.0217	-	-	.43	.0127	.0003	-	-
-	1889	-	-	0.33	5.08	1.62	.0025	.0210	.0177	.0033	.46	.0208	.0003	-	-
-	1890	-	-	0.21	4.74	1.03	.0016	.0184	.0149	.0035	.49	.0206	.0003	-	2.4
-	1891	-	-	0.24	4.66	1.44	.0017	.0182	.0145	.0037	.42	.0212	.0002	-	1.8
-	1892	-	-	0.15	4.61	1.35	.0018	.0168	.0133	.0035	.48	.0152	.0001	-	2.0
-	1893	-	-	0.21	4.64	1.58	.0015	.0168	.0138	.0030	.46	.0098	.0002	.3925	2.0
-	1894	-	-	0.20	4.76	1.59	.0008	.0163	.0137	.0026	.51	.0070	.0001	.3699	2.1

* June to December.

NOTE to analyses of 1894: Odor, vegetable; on heating, becoming also frequently unpleasant or grassy. —— The samples were collected in the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

BOSTON.

COCHITUATE SUPPLY.—*Microscopical Examination of Water from Lake Cochituate, in Wayland.*

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	2	3	4	3	5	3	2	5	3	2	3
Number of sample,	11578	11696	11827	11979	12138	12304	12460	12649	12868	13068	13245	13422
PLANTS.												
Diatomaceæ,	**593**	**880**	**102**	**1,092**	**1,866**	**827**	**8**	**6**	**17**	**354**	**510**	**1,568**
Asterionella,	242	640	54	370	920	5	0	0	0	252	424	1,480
Cyclotella,	36	20	1	54	84	280	3	1	1	1	8	0
Fragilaria,	7	0	0	10	0	0	0	0	0	59	29	10
Melosira,	194	142	40	440	416	12	0	4	0	20	49	68
Stephanodiscus,	0	0	0	2	4	0	0	0	0	0	0	10
Synedra,	0	pr.	0	112	2	10	1	1	16	22	0	0
Tabellaria,	114	78	7	104	440	520	4	0	0	0	0	0
Cyanophyceæ,	**0**	**22**	**16**	**0**	**0**	**7**	**23**	**16**	**12**	**99**	**332**	**0**
Anabæna,	0	0	0	0	0	7	19	10	5	10	332	0
Aphanocapsa,	0	0	0	0	0	0	0	0	0	84	0	0
Clathrocystis,	0	0	0	0	0	0	0	2	3	2	0	0
Microcystis,	0	2	0	0	0	0	4	4	4	2	0	0
Oscillaria,	0	20	16	0	0	0	0	0	0	1	0	0
Algæ,	**10**	**0**	**pr.**	**5**	**10**	**67**	**126**	**15**	**80**	**45**	**0**	**0**
Chlorococcus,	0	0	pr.	0	2	0	126	0	0	6	0	0
Glœocapsa,	0	0	0	2	0	0	0	0	0	9	0	0
Hyalotheca,	0	0	0	3	8	0	0	0	0	0	0	0
Protococcus,	10	0	0	0	0	15	0	15	80	30	0	0
Staurogenia,	0	0	0	0	0	16	0	0	0	0	0	0
Tetraspora,	0	0	0	0	0	36	0	0	0	0	0	0
ANIMALS.												
Rhizopoda,	**7**	**10**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Actinophrys,	7	10	1	2	0	0	0	0	0	0	0	0
Difflugia,	pr.	pr.	0	pr.	0	0	0	0	0	0	0	0
Infusoria,	**7**	**22**	**pr.**	**46**	**17**	**1**	**5**	**0**	**0**	**3**	**64**	**17**
Dinobryon,	0	2	0	0	0	0	1	0	0	0	2	0
Dinobryon cases,	2	5	pr.	22	12	0	0	0	0	0	60	0
Mallomonas,	0	0	0	16	3	0	0	0	0	1	1	0
Peridinium,	4	4	pr.	6	2	1	3	0	0	1	0	2
Synura,	0	8	0	0	0	0	0	0	0	0	1	11
Tintinnidium,	0	1	0	2	0	0	0	0	0	0	0	0
Trachelomonas,	1	2	0	pr.	0	0	1	0	0	1	0	4
Vermes,	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**1**	**4**
Anurea,	0	0	0	0	1	1	0	0	0	0	0	0
Rotifer,	0	0	0	0	0	1	0	0	0	0	1	4
Crustacea. Cyclops,	**0**	**.01**	**.02**	**.02**	**.01**	**0**	**0**	**0**	**.02**	**0**	**0**	**0**
Miscellaneous. Zoöglœa,	**18**	**0**	**6**	**11**	**140**	**0**	**24**	**7**	**0**	**3**	**0**	**0**
TOTAL,	635	934	125	1,156	2,034	904	186	44	109	504	907	1,589

BOSTON.

COCHITUATE WORKS. — *Chemical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11580	Jan. 2	V. slight.	Slight.	0.70	5.70	2.55	.0012	.0182	.0152	.0030	.47	.0080	.0001	.7316	1.9
11697	Feb. 1	Slight.	Slight.	0.75	5.05	2.20	.0004	.0154	.0132	.0022	.44	.0150	.0000	.6794	1.8
11828	Mar. 1	Slight.	Slight.	0.70	5.25	1.65	.0016	.0210	.0186	.0024	.45	.0180	.0000	.7000	1.7
11980	Apr. 2	Slight.	Cons.	0.60	4.35	1.85	.0006	.0174	.0148	.0026	.38	.0170	.0001	.5505	1.4
12126	May 1	V. slight.	Cons.	0.60	4.35	1.85	.0010	.0132	.0112	.0020	.41	.0130	.0000	.6043	1.4
12305	June 5	V. slight.	Slight.	0.65	4.20	1.60	.0004	.0146	.0126	.0020	.39	.0170	.0000	.5221	1.9
12461	July 2	Slight.	Slight.	0.85	4.55	2.00	.0000	.0184	.0166	.0018	.39	.0100	.0001	.7084	1.8
12651	Aug. 2	V. slight.	Slight.	0.60	4.50	1.10	.0000	.0156	.0142	.0014	.37	.0100	.0003	.5120	2.0
12869	Sept. 4	Slight.	V. slight.	0.70	4.45	1.50	.0008	.0186	.0170	.0016	.38	.0090	.0002	.5621	1.7
13069	Oct. 3	Slight.	Slight.	0.58	4.50	1.50	.0000	.0146	.0130	.0016	.44	.0030	.0000	.5688	1.6
13246	Nov. 1	Slight.	Slight.	0.50	4.10	1.65	.0006	.0172	.0162	.0010	.38	.0000	.0000	.5790	1.7
13421	Dec. 3	V. slight.	V. slight.	1.10	4.70	2.50	.0010	.0186	.0174	.0012	.43	.0070	.0000	.8354	1.7
Av.	....	....	....	0.69	4.64	1.83	.0006	.0169	.0150	.0019	.41	.0106	.0001	.6295	1.7

Averages by Years.

-	1887*	-	-	0.35	4.89	1.37	.0002	.0225	-	-	.41	.0094	-	-	-
-	1888	-	-	0.38	4.94	1.53	.0012	.0215	-	-	.40	.0183	.0002	-	-
-	1889	-	-	0.51	4.71	1.43	.0005	.0199	.0176	.0023	.42	.0272	.0002	-	-
-	1890	-	-	0.35	4.70	1.25	.0003	.0169	.0148	.0021	.42	.0241	.0001	-	2.2
-	1891	-	-	0.37	4.39	1.63	.0005	.0161	.0136	.0025	.37	.0227	.0001	-	1.7
-	1892	-	-	0.37	4.70	1.67	.0007	.0168	.0138	.0030	.41	.0210	.0001	-	1.9
-	1893	-	-	0.61	4.54	1.84	.0010	.0174	.0147	.0027	.38	.0143	.0001	.5976	1.8
-	1894	-	-	0.69	4.14	1.83	.0006	.0169	.0150	.0019	.41	.0106	.0001	.6295	1.7

* June to December.

NOTE to analyses of 1894: Odor, generally faintly vegetable. —— The odor generally became stronger on heating, and sometimes also mouldy.

BOSTON.

COCHITUATE WORKS. — *Microscopical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	2	3	4	2	6	3	2	5	3	2	5
Number of sample,	11580	11697	11828	11980	12126	12305	12461	12651	12869	13069	13246	13421
PLANTS.												
Diatomaceæ,	150	128	69	154	318	144	149	35	105	70	41	191
Asterionella,	88	50	50	40	49	0	2	8	88	36	2	152
Cyclotella,	14	2	1	3	15	76	68	0	0	1	3	12
Fragilaria,	0	0	0	0	0	0	0	0	0	6	8	0
Melosira,	29	24	14	43	34	0	2	0	0	0	7	0
Synedra,	5	28	1	6	52	0	1	4	0	1	0	0
Tabellaria,	14	24	3	62	168	68	76	23	17	26	21	27
Cyanophyceæ,	0	0	0	0	0	0	11	1	1	1	12	0
Anabæna,	0	0	0	0	0	0	7	0	1	1	11	0
Microcystis,	0	0	0	0	0	0	4	1	0	0	1	0
Algæ,	0	0	0	2	8	0	83	22	0	1	3	0
Chlorococcus,	0	0	0	2	0	0	79	0	0	0	3	0
Protococcus,	0	0	0	0	0	0	0	20	0	0	0	0
Scenedesmus,	0	0	0	0	0	0	4	2	0	1	0	0
Tetraspora,	0	0	0	0	8	0	0	0	0	0	0	0
Fungi. Crenothrix,	2	pr.	0	4	0	0	0	0	3	3	3	0
ANIMALS.												
Rhizopoda. Actinophrys,	0	2	3	0	0	0	0	0	0	0	0	0
Infusoria,	0	1	2	11	2	0	0	1	0	0	7	1
Cryptomonas,	0	0	0	3	0	0	0	0	0	0	0	0
Dinobryon cases,	0	pr.	1	4	0	0	0	0	0	0	6	0
Mallomonas,	0	0	0	1	0	0	0	0	0	0	1	0
Monas,	0	pr.	0	0	1	0	0	0	0	0	0	0
Peridinium,	0	pr.	1	1	1	0	0	1	0	0	0	0
Synura,	0	1	0	0	0	0	0	0	0	0	0	1
Vorticella,	0	0	0	2	0	0	0	0	0	0	0	0
Vermes. Rotifer,	0	0	0	0	0	0	0	0	0	2	0	0
Miscellaneous. Zoöglœa,	0	6	1	34	0	0	40	0	0	0	8	0
Total,	152	137	75	205	328	144	283	59	109	77	74	192

BOSTON.

MYSTIC SUPPLY. — *Chemical Examination of Water from Mystic Lake.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11568	Jan. 1	Slight.	Slight.	0.04	15.85	1.80	.0480	.0180	.0164	.0016	3.02	.0760	.0012	.2168	5.1
11686	Feb. 1	None.	V. slight.	0.05	15.55	2.55	.0600	.0132	.0118	.0014	2.98	.1000	.0015	.2275	5.1
11817	Mar. 1	Slight, milky.	Slight.	0.08	13.90	2.50	.0736	.0292	.0214	.0078	2.43	.0870	.0015	.4048	5.0
11968	Apr. 2	Slight.	Slight.	0.12	12.65	1.95	.0776	.0208	.0164	.0044	2.42	.0730	.0008	.2364	4.6
12141	May 1	Slight.	Cons.	0.18	11.90	2.10	.0374	.0234	.0168	.0066	2.18	.0600	.0015	.3000	4.0
12308	June 4	Distinct.	Cons., green.	0.15	12.85	2.65	.0320	.0280	.0174	.0106	2.49	.0650	.0008	.2964	4.2
12463	July 2	Distinct, green.	Slight, green.	0.05	12.90	2.30	.0062	.0206	.0160	.0046	2.82	.0580	.0010	.2618	4.2
12650	Aug. 1	Decided.	Cons., brown.	0.12	14.25	2.00	.0010	.0394	.0216	.0178	2.80	.0150	.0012	.2695	5.8
12870	Sept. 4	Slight.	Slight, brown.	0.12	14.45	3.50	.0016	.0228	.0162	.0066	2.94	.0350	.0006	.2156	4.9
13044	Oct. 1	Distinct.	Cons.	0.12	16.90	2.50	.0018	.0240	.0172	.0068	4.21	.0300	.0009	.2251	5.0
13251	Nov. 2	Decided.	Cons., earthy.	0.07	24.85	3.60	.0224	.0170	.0096	.0074	7.86	.0551	.0014	.2156	7.4
13411	Dec. 3	Distinct.	Slight.	0.18	21.20	3.25	.0952	.0260	.0208	.0052	5.56	.0450	.0015	.2603	6.9
Av.	....	....	....	0.11	15.60	2.56	.0381	.0235	.0168	.0067	3.48	.0583	.0012	.2608	5.2

Averages by Years.

-	1887*	-	-	0.28	10.82	1.62	.0114	.0266	-	-	2.06	.0263	-	-	-
-	1888	-	-	0.21	10.12	1.76	.0244	.0267	-	-	1.94	.0433	.0016	-	-
-	1889	-	-	0.26	9.02	1.97	.0211	.0278	.0209	.0069	1.67	.0586	.0012	-	-
-	1890	-	-	0.13	10.65	1.78	.0197	.0223	.0183	.0040	1.57	.0796	.0008	-	3.7
-	1891	-	-	0.13	9.50	1.81	.0186	.0242	.0187	.0055	1.58	.0731	.0012	-	3.5
-	1892	-	-	0.07	11.52	2.09	.0185	.0206	.0153	.0053	2.22	.0698	.0007	-	4.1
-	1893	-	-	0.10	12.62	2.17	.0240	.0215	.0159	.0056	2.49	.0583	.0007	-	4.4
-	1894	-	-	0.11	15.60	2.56	.0381	.0235	.0168	.0067	3.48	.0583	.0012	.2608	5.2

* June to December.

NOTE to analyses of 1894: Odor, generally unpleasant, mouldy or disagreeable, becoming stronger on heating. —— The larger amount of residue on evaporation and of chlorine in the last three samples was due to the infiltration of sea water when the lake was drawn to an unusually low level. The samples were collected from the lake, near the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

BOSTON.

MYSTIC SUPPLY. — *Microscopical Examination of Water from Mystic Lake.*

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Jan.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	1	31	2	3	3	6	3	2	5	2	3	3
Number of sample,	11568	11686	11817	11968	12141	12308	12463	12650	12870	13044	13251	13411
PLANTS.												
Diatomaceæ,	**3,206**	**360**	**70**	**351**	**745**	**11,020**	**9,744**	**1,604**	**734**	**692**	**6,582**	**2,480**
Asterionella,	0	0	28	120	240	0	0	0	0	0	0	0
Fragilaria,	6	0	0	13	100	220	0	1,600	14	412	10	0
Melosira,	0	0	10	34	5	0	0	0	0	0	12	0
Synedra,	3,200	360	32	184	400	10,800	9,744	4	720	280	6,560	2,480
Algæ,	**44**	**2**	**2**	**13**	**393**	**715**	**300**	**580**	**600**	**295**	**112**	**28**
Arthrodesmus,	0	0	0	0	0	0	48	0	0	0	0	0
Chlorococcus,	0	0	0	0	1	13	0	0	0	0	0	0
Protococcus,	0	0	0	5	10	20	0	0	0	0	0	0
Scenedesmus,	44	2	2	8	380	680	252	580	600	292	112	28
Staurastrum,	0	0	0	0	2	2	0	0	0	3	0	0
Fungi. Crenothrix,	**32**	**4**	**0**	**38**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.												
Infusoria,	**0**	**2**	**1**	**pr.**	**13**	**33**	**120**	**1,513**	**81**	**422**	**14**	**2**
Encysted protozoön,	0	0	0	pr.	0	1	0	0	0	0	0	0
Monas,	0	1	1	0	1	32	0	1	1	2	0	0
Peridinium,	0	1	0	0	2	0	120	1,512	80	420	14	2
Trachelomonas,	0	0	0	pr.	1	0	0	0	0	0	0	0
Vorticella,	0	0	0	0	2	0	0	0	0	0	0	0
Vorticella stems,	0	0	0	0	7	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	**3**	**16**	**120**	**86**	**94**	**20**	**24**	**0**	**108**	**88**	**0**	**148**
TOTAL,	3,285	384	193	488	1,246	11,788	10,188	3,697	1,523	1,497	6,708	2,658

BOSTON.

Examination of Water from Lower Mystic Lake for Chlorine and Organisms.

NOTE. —— This lake is a tidal basin, and not a source of water supply.

	1894.			
	November.	November.	November.	November.
Day of examination,	13	13	13	13
Number of sample,	13286	13287	13288	13289
Chlorine (parts per 100,000),	442	535	549	399
PLANTS.				
Diatomaceæ,	**1,367**	**1,359**	**1,558**	**1,307**
Cyclotella,	2	2	4	3
Melosira,	0	0	0	11
Orthosira,	1,360	1,354	1,552	1,290
Synedra,	5	3	2	3
Algæ,	**4**	**0**	**0**	**4**
Conferva,	3	0	0	0
Scenedesmus,	1	0	0	4
ANIMALS.				
Infusoria,	**1**	**2**	**2**	**3**
Monas,	.0	0	1	0
Paramæcium,	0	0	0	1
Peridinium,	1	0	0	0
Synura,	0	0	0	1
Trichodina,	0	2	1	1
Total number of organisms,	1,372	1,361	1,560	1,314

*Chemical Examination of Water from Jamaica Pond, at Various Depths.**

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12798	Aug. 22	Decided, white.	Slight, white.	0.03	–	–	.0000	.0396	.0158	.0138	–	.0000	.0000	.2849	–
12799	Aug. 22	Decided, green.	Slight, white.	0.03	6.80	1.70	.0000	.0420	.0158	.0262	.94	.0000	.0000	–	2.7
12800	Aug. 22	Distinct, white.	V. slight.	0.01	–	–	.0000	.0316	.0086	.0230	–	.0100	.0001	–	–
12801	Aug. 22	Decided, white.	Slight, yellow.	0.03	–	–	.0010	.0346	.0102	.0244	–	.0200	.0002	–	–
12802	Aug. 22	Decided.	Slight.	0.00	–	–	.6080	.0536	.0220	.0316	–	.0040	.0003	–	–

* The use of this pond as a source of public water supply has been permanently discontinued.

Iron in the second sample, .0100; in the last, .6000. Odor of the first four samples, none; that of the first three, becoming distinct on heating; odor of the last sample, offensive. —— The samples were collected, in the order of their numbers, at the following depths, in feet, beneath the surface: 0, 10, 20, 30 and 40. The color of the last sample after standing one day was 5.00, and was a bright yellow.

BOSTON.

Microscopical Examination of Water from Jamaica Pond, at Various Depths.

[Number of organisms per cubic centimeter.]

	1894.				
	August.	August.	August.	August.	August.
Day of examination,	23	23	23	23	23
Number of sample,	12798	12799	12800	12801	12802
PLANTS.					
Diatomaceæ,	**0**	**0**	**32**	**7**	**0**
Cymbella,	0	0	0	1	0
Synedra,	0	0	32	6	0
yanophyceæ,	**4,816**	**2,661**	**1,672**	**1,840**	**2,200**
Anabæna,	1,080	1,000	32	0	0
Clathrocystis,	0	1	0	0	0
Oscillaria,	3,736	1,660	1,640	1,840	2,200
ANIMALS.					
Rhizopoda. Actinophrys,	**1**	**0**	**0**	**0**	**0**
Infusoria,	**23**	**17**	**0**	**5**	**1**
Ceratium,	17	14	0	1	0
Ciliated infusorian,	0	1	0	1	0
Monas,	0	0	0	3	1
Peridinium,	5	2	0	0	0
Vorticella,	1	0	0	0	0
Vermes,	**1**	**1**	**0**	**1**	**0**
Anurea,	1	0	0	0	0
Monocerca,	0	1	0	0	0
Polyarthra,	0	0	0	1	0
Miscellaneous. Zoöglœa,	**5**	**0**	**0**	**20**	**0**
TOTAL,	4,846	2,679	1,704	1,873	2,201

BOSTON.

Table showing the Heights in Feet above Tide-marsh Level on the First of each Month of the Water in the Lakes and Storage Reservoirs of the Boston Water Works, from which Samples of Water were collected during the Year 1894.

	Reservoir No. 2. Flash Boards, 167.12	Reservoir No. 3. Stone Crest, 175.24	Reservoir No 4. Flash Boards, 215.21	Reservoir No. 6. Flash Boards, 295.00	Farm Pond. High Water, 149.25	Lake Cochituate. High Water, 134 36	Mystic Lake. High Water, 7.00
1894.							
Jan. 1, .	160.17	168.53	178.83	-	148.74	127.94	3.85
Feb. 1, .	160.61	172.32	185.92	259.33	148.98	127.59	5.85
March 1, .	166.12	175.54	192.70	268.42	149.27	128.22	4.87
April 1, .	166.01	175.40	204.84	281.52	149.32	132.60	6.45
May 1, .	166.02	175.39	211.39	288.26	149.50	134.13	6.37
June 1, .	167.24	175.54	214.60	291.08	149.39	134.24	6.67
July 1, .	162.92	172.62	215.26	292.66	149.03	133.24	5.46
Aug. 1, .	162.02	169.29	207.36	292.68	148.66	131.59	2.35
Sept. 1, .	162.57	170.92	191.63	292.54	148.34	129.88	—1.45
Oct. 1, .	162.94	170.95	185.54	283.30	148.19	128.14	—4.47
Nov. 1, .	164.08	172.77	187.55	274.23	148.34	126.74	—3.72
Dec. 1, .	164.55	175.40	191.90	275.29	148.49	126.27	0.67

Water Supply of Bradford. — Bradford Water Company.

In the last annual report it was noted that a progressive deterioration of this water, as compared with previous years, had occurred, and that the organic matter as shown by the albuminoid ammonia, and the product of its decomposition as shown by the free ammonia, were decidedly on the increase. The deterioration of the water has continued during 1894 in even a more marked degree than in previous years, there being in particular a very great increase in free ammonia and in iron. In view of this condition of the water, the Bradford Water Company applied to the State Board of Health, in the latter part of 1894, for advice as to a proposed new supply, and as to improving the present supply pending the introduction of a new one. The town has decided to acquire possession of the works, and, it is said, will assume control of them April 1, 1895.

The water now used is drawn, as stated in previous reports, from several large wells having a wooden curbing, and a considerable area of water surface is exposed to the air. The water as it first comes from the ground may be nearly or quite clear and colorless; but, owing to the oxidation of the iron which it contains in solution, it quickly becomes turbid and colored. An extended statement with regard to this change is given on pages 120 and 121 of the annual report of the Board for 1893.

BRADFORD.

Analyses of samples of water from the present sources and from Chadwick's Pond are given below; and an analysis of a sample of water from Johnson's Pond, one of the proposed sources of supply, may be found under Groveland.

Chemical Examination of Water from the Wells of the Bradford Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11604	Jan. 4	Distinct, milky.	V. slight.	0.50	7.40	.0382	.0046	.30	.1100	.0006	–	2.6	.1150
11737	Feb. 8	Decided, milky.	Cons., rusty.	0.55	5.60	.0388	.0046	.30	.0400	.0001	.1120	2.1	.1550
11859	Mar. 7	Distinct, milky.	Cons., rusty.	0.30	5.50	.0394	.0066	.27	.0250	.0008	.1280	2.1	.1360
12029	Apr. 11	Distinct, milky.	Slight.	0.25	4.80	.0310	.0054	.32	.0350	.0002	.0869	1.9	.1220
12181	May 9	Distinct, milky.	Slight, rusty.	0.30	6.60	.0294	.0034	.29	.0070	.0040	.1312	3.4	.0580
12353	June 12	Slight, milky.	None.	0.40	6.90	.0274	.0034	.25	.0180	.0009	.0847	2.9	.0960
12514	July 11	Decided, milky.	Cons., rusty.	0.60	5.70	.0502	.0036	.27	.0130	.0002	.1609	1.9	.1450
12744	Aug. 14	Decided, milky.	Cons., rusty.	0.05	7.20	.0526	.0092	.24	.0050	.0012	.0662	2.5	.2000
12910	Sept. 10	Distinct, milky.	V. slight.	0.50	6.00	.0462	.0048	.26	.0100	.0003	.0924	2.9	.0750
12980	Sept. 18	Distinct, milky.	Slight.	0.50	5.70	.0544	.0046	.29	.0100	.0000	.1347	1.8	.1900
13099	Oct. 8	Distinct, milky.	Slight, rusty.	0.60	6.50	.0416	.0092	.28	.0050	.0012	.1254	2.3	.1980
13284	Nov. 9	Decided, milky.	V. slight.	0.70	5.10	.0402	.0068	.28	.0150	.0002	.1963	2.3	.1900
13444	Dec. 3	Decided, milky.	V. slight.	0.45	5.90	.0520	.0056	.29	.0100	.0003	.1424	2.3	.1960
Av.	....	....	....	0.43	6.08	.0409	.0056	.28	.0244	.0008	.1225	2.4	.1453

Averages by Years.

–	1889*	–	–	0.00	3.95	.0000	.0014	.21	.0400	.0000	–	1.6	–
–	1890†	–	–	0.00	5.30	.0002	.0036	.34	.0150	.0001	–	2.6	–
–	1891‡	–	–	0.04	5.40	.0000	.0027	.23	.0350	.0001	–	1.8	–
–	1892	–	–	0.03	6.59	.0262	.0029	.28	.0760	.0003	–	2.4	–
–	1893	–	–	0.33	5.80	.0297	.0047	.30	.0475	.0008	.0994	2.5	.0774
–	1894	–	–	0.43	6.08	.0409	.0056	.28	.0244	.0008	.1225	2.4	.1453

* July. † October. ‡ April, two samples.

NOTE to analyses of 1894: Odor, generally distinct, frequently unpleasant. —— Nos. 11737, 12514 and 12980 were collected from a faucet at the pumping station, and the other samples from faucets in the town.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 204, chiefly Crenothrix and Zoöglœa.

BRADFORD.

Chemical Examination of Water from the Distributing Reservoir of the Bradford Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
12981	1894. Sept. 18	Slight, milky.	Cons., gray.	0.50	5.70	–	.0384	.0122	.0104	.0018	.33	.0200	.0004	.1925	1.8

Iron, .1000. Odor, faintly vegetable. —— The sample was collected from the distributing reservoir.

Microscopical Examination.

Diatomaceæ, *Synedra*, 1. Algæ, *Chlorococcus*, 2. Fungi, *Crenothrix*, 1. Miscellaneous, *Zoöglœa*, 32. Total, 36.

Chemical Examination of Water from Chadwick's Pond, Bradford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
12902	1894. Sept. 6	V. slight.	Slight.	0.10	5.30	1.70	.0002	.0208	.0180	.0028	.35	.0020	.0000	.3542	1.9

Iron, .0100. Odor, faintly vegetable and mouldy. —— The sample was collected from the pond, 300 feet from the east shore, in connection with an investigation for a new water supply for Bradford.

Microscopical Examination.

No. 12902. Diatomaceæ, *Asterionella*, 14; *Cyclotella*, 1; *Melosira*, 1. Cyanophyceæ, *Chroöcoccus*, 8; *Clathrocystis*, 13; *Microcystis*, 1. Algæ, *Protococcus*, 32. Vermes, *Polyarthra*, 1. Crustacea, *Cyclops*, .01. Miscellaneous, *Acarina*, .02. *Zoöglœa*, 34. Total, 105.

BRAINTREE.

Water Supply of Braintree.

In 1893 a direct connection was made between the filter-gallery of the Braintree water works and Little Pond by running a 12-inch main from the pond into the filter-gallery. The filter-gallery furnished a sufficient supply without the use of water from the pond until July 12. Between that date and September 3 water was drawn from the pond into the filter-gallery for the supply of the town for a total of forty-three hours.

Chemical Examination of Water from the Filter-gallery of the Braintree Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11603	Jan. 3	None.	None.	0.00	5.55	.0000	.0030	.92	.0700	.0000	.0858	2.1	.0040
11725	Feb. 7	None.	None.	0.00	5.10	.0012	.0068	.85	.0350	.0000	.1184	1.7	.0050
11854	Mar. 7	None.	None.	0.05	4.90	.0004	.0062	.84	.0580	.0000	.1800	1.7	.0050
12034	Apr. 11	V. slight.	None.	0.00	4.80	.0000	.0050	.84	.0630	.0000	.1540	1.6	.0100
12174	May 8	None.	V. slight.	0.05	4.50	.0000	.0044	.81	.0450	.0000	.1804	1.3	.0135
12343	June 11	V. slight.	V. slight.	0.10	4.25	.0002	.0054	.80	.0170	.0000	.0077	1.4	–
12551	July 15	None.	V. slight.	0.07	5.25	.0006	.0048	.82	.0120	.0000	.1140	1.4	.0105
12729	Aug. 13	V. slight.	V. slight.	0.03	5.50	.0000	.0030	.80	.0050	.0001	.0847	1.5	.0200
12916	Sept. 10	Distinct.	Slight.	0.07	5.30	.0010	.0040	.83	.0080	.0002	.0847	1.8	.0400
13094	Oct. 8	Slight.	V. slight.	0.02	5.50	.0000	.0058	.86	.0050	.0003	.0760	2.2	.0230
13281	Nov. 8	None.	None.	0.03	5.45	.0002	.0032	.92	.0300	.0008	.0462	1.9	.0075
13438	Dec. 5	Distinct.	Cons., brown.	0.02	6.20	.0010	.0056	1.00	.0580	.0000	.0678	1.9	.0230
Av.	....	....	....	0.04	5.19	.0004	.0048	.86	.0338	.0001	.1000	1.7	.0135

Averages by Years.

–	–*	–	–	0.07	7.14	.0006	.0045	.85	.0948	.0003	–	–	–
–	1892	–	–	0.02	4.69	.0002	.0030	.75	.0192	.0001	–	1.8	–
–	1893	–	–	0.03	4.72	.0002	.0049	.83	.0363	.0001	.1029	1.8	.0037
–	1894	–	–	0.04	5.19	.0004	.0048	.86	.0338	.0001	.1000	1.7	.0135

* June, 1887, to May, 1888.

Note to analyses of 1894: Odor in March and December, faintly vegetable; in August, distinct; at other times, none. On heating, the odor of the March and December samples disappeared, and the odor of the October sample was distinctly vegetable and unpleasant. —— The samples were collected from a faucet at the pumping station. Water was drawn from Little Pond into the filter-gallery as follows: July 12, 13, 14, 20, 29, September 2 and 3.

BRAINTREE.

Microscopical Examination of Water from the Filter-gallery of the Braintree Water Works.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	5	8	8	13	10	13	17	14	12	9	10	7
Number of sample, . .	11603	11725	11854	12034	12174	12343	12551	12729	12916	13094	13281	13438
PLANTS.												
Fungi. Crenothrix, .	0	0	10	0	0	8	0	210	0	20	3	160
ANIMALS.												
Infusoria, ...	16	1	4	0	0	0	4	0	0	0	0	0
Dinobryon, . .	0	0	1	0	0	0	4	0	0	0	0	0
Dinobryon cases, .	0	0	3	0	0	0	0	0	0	0	0	0
Peridinium, . .	16	1	0	0	0	0	0	0	0	0	0	0
Miscellaneous. Zoöglœa,	0	0	0	0	0	38	0	7	580	380	0	0
TOTAL, ...	16	1	14	0	0	46	4	217	580	400	3	160

Chemical Examination of Water from a Faucet supplied from the Braintree Water Works.

[Parts per 100,000]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
13045	1894. Sept.30	Slight.	Heavy, brown.	0.05	5.25	0.90	.0002	.0220	.0078	.0142	.92	.0130	.0000	.0948	1.8

Iron, .0900. Odor, none. —— The sample was collected from a faucet, three miles from the pumping station.

Microscopical Examination.

Diatomaceæ, *Synedra*, 4. Cyanophyceæ, *Clathrocystis*, 4. Fungi, *Crenothrix*, 3,016. Total, 3,024.

BRAINTREE.

Chemical Examination of Water from Little Pond, Braintree.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11724	Feb. 7	V. slight.	V. slight.	0.18	4.50	1.70	.0026	.0314	.0242	.0072	.85	.0050	.0000	.4560	1.1
12173	Mar. 8	V. slight.	Slight.	0.30	3.95	1.55	.0002	.0170	.0148	.0022	.72	.0030	.0000	.4494	0.8
12728	Aug. 13	Distinct.	Slight.	0.25	3.45	1.05	.0004	.0238	–	–	.77	.0000	.0000	.3426	0.8
13280	Nov. 8	Slight.	Slight.	0.25	4.20	1.35	.0026	.0234	.0182	.0052	.82	.0000	.0000	.3888	1.1
Av.	....	....	....	0.25	4.03	1.41	.0015	.0239	.0191	.0048	.79	.0020	.0000	.4092	1.0

Odor of all samples, vegetable, and of the August sample also mouldy; the odor of the last two samples became stronger on heating. —— The samples were collected from the pond.

Microscopical Examination of Water from Little Pond, Braintree.

[Number of organisms per cubic centimeter.]

	1894. February.	1894. May.	1894. August.	1894. November.
Day of examination,	8	10	14	10
Number of sample,	11724	12173	12728	13280
PLANTS.				
Diatomaceæ,	**0**	**43**	**pr.**	**24**
Cyanophyceæ,	**0**	**1**	**29**	**78**
Anabæna,	0	0	3	0
Chroöcoccus,	0	1	2	0
Clathrocystis,	0	0	24	2
Merismopedia,	0	0	0	4
Microcystis,	0	0	0	72
Algæ,	**7**	**0**	**25**	**18**
Arthrodesmus,	0	0	2	3
Nephrocytium,	0	0	4	0
Protococcus,	0	0	15	3
Raphidium,	0	0	4	12
Tetraspora,	4	0	0	0
Zoöspores,	3	0	0	0
Fungi, Crenothrix,	**0**	**4**	**0**	**3**
ANIMALS.				
Rhizopda. Microgromia,	**4**	**0**	**0**	**0**
Infusoria,	**864**	**0**	**1**	**1**
Dinobryon,	800	0	0	0
Dinobryon cases,	52	0	1	0
Monas,	1	0	0	0
Peridinium,	9	0	pr.	1
Tintinnidium,	1	0	0	0
Trachelomonas,	1	0	pr.	0
Miscellaneous, Zoöglœa,	**0**	**44**	**80**	**0**
Total,	875	92	135	124

Water Supply of Brockton.

The advice of the State Board of Health to the city of Brockton, relative to increasing the water supply of the city and providing a high-service supply for certain districts, may be found on pages 12 and 13 of this volume.

It has already been indicated in previous reports that the quality of the water supplied to the city improved very much from 1887 to 1891, and remained nearly constant after 1891. It will be seen, by reference to the table of averages by years on the following page, that the average analysis for 1894 is very nearly the same as those of the three years immediately preceding.

On five occasions during the first half of 1894 samples of water were collected before and after passing through the open tank, in which the water is aerated by forcing air into it through a system of perforated pipes laid near the bottom of the tank. By reference to the table on page 118, giving the comparison of examinations before and after aeration, it will be observed that the aeration does not cause any material change in the character of the water, so far as can be determined by the examination of samples.

Chemical Examination of Water from Salisbury Brook, at the Point where it enters the Storage Reservoir of the Brockton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
12147	May 2	Distinct.	Slight, brown.	0.70	3.10	1.35	.0004	.0172	.0152	.0020	.41	.0000	.0000	.6800	0.3
12491	July 9	Slight.	Slight.	1.20	4.00	2.20	.0006	.0314	.0286	.0028	.47	.0000	.0000	.8478	0.5

Odor of the first sample, decidedly vegetable and sweetish, becoming unpleasant and oily on heating; of the second sample, distinctly vegetable and sweetish, becoming faintly mouldy on heating. —— The samples were collected from the brook, just above the reservoir.

Microscopical Examination.

No. 12147. Diatomaceæ, *Asterionella*, 55; *Cymbella*, 1; *Diadesmus*, 10; *Melosira*, 36; *Synedra*, 7; *Tabellaria*, 35. Cyanophyceæ, *Anabæna*, 2; Algæ, *Arthrodesmus*, 2; *Conferva*, 1. Fungi, *Crenothrix*, 2. Infusoria, *Dinobryon cases*, 14; *Peridinium*, 1. Total, 166.

No. 12491. Diatomaceæ, *Asterionella*, 4; *Diatoma*, 1; *Synedra*, 20; *Tabellaria*, 580. Algæ, *Conferva*, 1; *Cosmarium*, 1; *Pandorina*, 2; *Scenedesmus*, 1. Fungi, *Crenothrix*, 28. Infusoria, *Peridinium*, 4; *Trachelomonas*, 2; Vermes, *Monocerca*, 1; *Polyarthra*, 1. Total, 646.

BROCKTON.

Chemical Examination of Water from Salisbury Brook Storage Reservoir, Brockton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11587	Jan. 2	Slight.	Cons., rusty.	0.75	4.60	2.25	.0016	.0272	.0198	.0074	.44	.0020	.0000	.7683	0.6
11712	Feb. 5	Slight.	Slight.	0.70	4.15	2.00	.0028	.0198	.0168	.0030	.45	.0000	.0000	.8000	0.8
11839	Mar. 5	Slight.	Slight.	0.80	4.00	1.80	.0008	.0176	.0156	.0020	.43	.0030	.0000	.7424	0.6
11982	Apr. 2	Slight.	Slight.	0.68	3.55	1.65	.0000	.0164	.0140	.0024	.37	.0030	.0000	.5783	0.2
12148	May 2	Decided.	Cons.	0.75	2.85	1.10	.0008	.0206	.0154	.0052	.41	.0000	.0000	.7232	0.3
12315	June 5	Distinct.	Cons., yellow.	0.90	3.40	1.65	.0006	.0226	.0196	.0030	.36	.0050	.0000	.7084	0.6
12492	July 9	Distinct.	Slight, yellow.	0.90	3.40	1.60	.0004	.0238	.0218	.0020	.45	.0000	.0000	.6730	0.4
12676	Aug. 7	Slight.	Slight, brown.	0.75	3.45	1.55	.0000	.0222	.0198	.0024	.43	.0020	.0000	.5890	0.8
12884	Sept. 5	Distinct.	Cons., brown.	0.80	3.30	1.20	.0002	.0248	.0210	.0038	.42	.0000	.0001	.5082	0.6
13078	Oct. 3	Distinct.	Cons.	0.80	3.35	1.45	.0060	.0262	.0188	.0074	.45	.0000	.0000	.5530	0.5
13265	Nov. 6	Distinct.	Cons., green.	0.88	4.00	1.55	.0010	.0278	.0206	.0072	.50	.0050	.0000	.5775	1.3
13437	Dec. 5	Distinct.	Slight.	0.95	4.50	1.70	.0002	.0250	.0226	.0024	.51	.0050	.0000	.7438	1.1
Av.				0.81	3.71	1.63	.0012	.0228	.0188	.0040	.44	.0021	.0000	.6638	0.7

Averages by Years.

-	1887*	-	-	0.99	4.94	2.25	.0033	.0541	-	-	.33	.0069	-	-	-
-	1888	-	-	0.76	3.77	1.61	.0031	.0369	-	-	.31	.0066	.0001	-	-
-	1889	-	-	0.78	2.79	1.01	.0028	.0306	.0218	.0078	.30	.0048	.0002	-	-
-	1890	-	-	0.75	4.07	1.98	.0016	.0274	.0219	.0055	.32	.0063	.0001	-	0.9
-	1891	-	-	0.62	3.15	1.45	.0010	.0213	.0169	.0044	.28	.0061	.0001	-	0.6
-	1892	-	-	0.55	3.41	1.37	.0004	.0213	.0168	.0045	.36	.0030	.0000	-	0.7
-	1893	-	-	0.67	3.59	1.70	.0007	.0237	.0196	.0041	.40	.0019	.0001	.6545	0.7
-	1894	-	-	0.81	3.71	1.63	.0012	.0228	.0188	.0040	.44	.0021	.0000	.6638	0.7

* June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable, sometimes mouldy, unpleasant or disagreeable. In May the odor became oily on heating. —— The samples were collected from the reservoir, near the gate-house, 1 foot beneath the surface. For a record of heights of water in this reservoir on dates when samples of water were collected for analysis, see page 119.

BROCKTON.

Microscopical Examination of Water from Salisbury Brook Storage Reservoir, Brockton.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	4	6	6	4	3	6	10	8	6	5	8	7
Number of sample, . .	11587	11712	11839	11982	12148	12315	12492	12676	12884	13078	13265	13437
PLANTS.												
Diatomaceæ, . .	384	10	21	103	252	610	2,973	377	2,389	798	750	36
Asterionella, . .	52	4	21	27	92	28	0	168	32	60	72	7
Diatoma, . . .	4	0	0	0	4	0	3	0	1	1	0	0
Melosira, . . .	148	0	0	24	104	145	10	0	116	516	482	0
Synedra, . . .	28	0	0	1	4	1	0	5	480	1	28	4
Tabellaria, . . .	152	6	pr.	51	48	436	2,960	204	1,760	220	168	25
Algæ, ...	2	pr.	0	2	2	20	12	9	15	90	58	2
Arthrodesmus, . .	2	pr.	0	0	0	0	0	3	2	7	0	0
Chlorococcus, . .	0	0	0	0	0	4	0	0	0	2	4	2
Closterium, . . .	0	0	0	0	0	0	0	0	0	56	0	0
Pediastrum, . . .	0	0	0	0	0	0	0	0	2	5	2	0
Protococcus, . .	0	0	0	2	0	15	10	0	0	4	4	0
Raphidium, . . .	0	0	0	0	0	0	0	6	8	8	0	0
Scenedesmus, . .	0	0	0	pr.	2	1	2	0	3	8	48	0
Fungi. Crenothrix, .	2	0	0	0	6	0	0	0	0	0	0	0
ANIMALS.												
Rhizopoda, Difflugia, .	2	0	0	0	0	0	0	0	2	1	11	0
Infusoria, . . .	2	195	64	120	43	7	224	92	13	3	42	52
Dinobryon, . . .	0	17	0	0	0	0	0	0	0	0	0	0
Dinobryon cases, .	0	108	28	78	38	0	0	0	0	0	0	0
Euglena, . . .	0	pr.	0	0	0	0	0	0	1	0	0	0
Mallomonas, . .	0	0	0	0	0	3	0	0	0	0	0	0
Peridinium, . . .	2	70	36	42	5	4	224	92	10	0	40	52
Tintinnidium, . .	0	0	0	0	0	0	0	0	0	2	0	0
Trachelomonas, .	0	0	0	0	0	0	0	0	2	1	2	0
Vermes, ...	3	1	pr.	pr.	0	0	1	0	1	1	2	2
Anurea, . . .	2	pr.	0	pr.	0	0	1	0	1	1	0	0
Polyarthra, . . .	1	1	0	pr.	0	0	0	0	0	0	2	1
Rotatorian ova, . .	0	pr.	pr.	pr.	0	0	0	0	0	0	0	0
Rotifer, . . .	0	pr.	0	0	0	0	0	0	0	0	0	1
Crustacea, . . .	0	0	0	0	.02	0	.01	0	.01	.03	0	0
Cyclops, . . .	0	0	0	0	0	0	0	0	.01	.03	0	0
Crustacean remains, .	0	0	0	0	.02	0	.01	0	0	0	0	0
Miscellaneous. Zoöglœa, .	68	0	0	5	0	52	240	600	400	680	228	0
TOTAL, ...	463	206	85	230	303	689	3,450	1,078	2,820	1,573	1,091	92

BROCKTON.

Comparison of Examinations of Water from the Brockton Water Works before and after Aeration in the Open Tank.

NOTE. — Figures in bold-face type show results of examinations before aeration. Figures in Roman type show results of examinations after aeration.

Number.	Date of Collection.	Appearance.			Odor.	
		Turbidity.	Sediment.	Color.	Cold.	Hot.
	1894.					
11587	**Jan. 2**	**Sli't.**	**Cons., rusty.**	**0.75**	**Distinctly vegetable and aromatic.**	**Distinctly vegetable.**
11588	Jan. 2	V. slight.	Slight.	0.80	Distinctly vegetable and aromatic.	Distinctly vegetable.
11712	**Feb. 5**	**Sli't.**	**Sli't.**	**0.70**	**Distinctly vegetable, sweetish.**	**Distinctly vegetable, sweetish.**
11711	Feb. 5	Dist't.	Heavy, dark, earthy.	0.80	Distinctly vegetable, sweetish.	Distinctly vegetable, sweetish.
11839	**Mar. 5**	**Sli't.**	**Sli't.**	**0.80**	**Distinctly vegetable, sweetish.**	**Distinctly vegetable, sweetish.**
11840	Mar. 5	Slight.	Heavy, brown.	0.80	Distinctly vegetable, sweetish.	Faintly vegetable.
11982	**Apr. 2**	**Sli't.**	**Sli't.**	**0.68**	**Distinctly vegetable and earthy.**	**Distinctly vegetable, sweetish.**
11981	Apr. 2	Slight.	Cons., dark, brown.	0.70	Distinctly vegetable, sweetish.	Decidedly vegetable and mouldy.
12315	**June 5**	**Dist't.**	**Cons., yellow.**	**0.90**	**Decidedly vegetable and mouldy.**	**Decidedly vegetable, sweetish.**
12316	June 5	Slight.	Cons., rusty.	0.85	Decidedly vegetable and mouldy.	Decidedly vegetable and sweetish.
Av.	....	....	....	**0.77**	....	....
Av.	....	....	....	0.79	....	....

Comparison of Examinations of Water from the Brockton Water Works before and after Aeration in the Open Tank — Concluded.

[Parts per 100,000.]

Number.	Date of Collection.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.	Organisms per Cubic Centimeter.
					Albuminoid.									
		Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.				
	1894.													
11587	**Jan. 2**	**4.60**	**2.25**	**.0016**	**.0272**	**.0198**	**.0074**	**.44**	**.0020**	**.0000**	**.7683**	**0.6**	**.0235**	**463**
11588	Jan. 2	4.30	1.95	.0000	.0206	.0184	.0022	.41	.0000	.0000	.8229	0.5	.0225	55
11712	**Feb. 5**	**4.15**	**2.00**	**.0028**	**.0198**	**.0168**	**.0030**	**.45**	**.0000**	**.0000**	**.8000**	**0.8**	**.0360**	**206**
11711	Feb. 5	4.05	2.05	.0050	.0242	.0178	.0064	.46	.0050	.0000	.7200	0.8	.0360	435
11839	**Mar. 5**	**4.00**	**1.80**	**.0008**	**.0176**	**.0156**	**.0020**	**.43**	**.0030**	**.0000**	**.7424**	**0.6**	**.0300**	**85**
11840	Mar. 5	4.05	1.80	.0006	.0212	.0174	.0038	.43	.0030	.0000	.7400	0.6	.0290	98
11982	**Apr. 2**	**3.55**	**1.65**	**.0000**	**.0164**	**.0140**	**.0024**	**.37**	**.0030**	**.0000**	**.5783**	**0.2**	**.0260**	**230**
11981	Apr. 2	3.35	1.40	.0000	.0190	.0138	.0052	.36	.0000	.0000	.5529	0.2	.0200	330
12315	**June 5**	**3.40**	**1.65**	**.0006**	**.0226**	**.0186**	**.0030**	**.36**	**.0050**	**.0000**	**.7084**	**0.6**	**–**	**689**
12316	June 5	3.35	1.60	.0014	.0234	.0190	.0044	.38	.0030	.0000	.7045	0.6	–	471
Av.	....	**3.94**	**1.87**	**.0012**	**.0207**	**.0172**	**.0035**	**.41**	**.0026**	**.0000**	**.7195**	**0.6**	**.0289**	**335**
Av.	....	3.82	1.76	.0014	.0217	.0173	.0044	.41	.0022	.0000	.7081	0.5	.0269	287

BROCKTON.

Table showing Height of Water in Salisbury Brook Storage Reservoir, Brockton, on the First Day of Each Month in 1894.

[NOTE. — High-water mark is 14.25 feet.]

DATE.	Height of Water.	DATE.	Height of Water.
1894.	Feet.	1894.	Feet.
Jan. 1,	14.25	July 1,	13.67
Feb. 1,	14.25	Aug. 1,	11.92
March 1,	14.25	Sept. 1,	10.17
April 1,	14.25	Oct. 1,	8.73
May 1,	14.25	Nov 1,	9.90
June 1,*	14.75	Dec. 1,	14.25

* In the latter part of May, 1894, the water was raised temporarily 6 inches above high-water mark.

Chemical Examination of Water from Underdrains beneath the Sewers at Brockton

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11664	Jan. 19	Slight, milky.	Slight, rusty.	0.02	15.10	.0640	.0060	1.82	.2100	.0050	.0671	3.9	.1240
12477	July 5	Distinct, milky.	Cons., sand.	0.05	15.90	.7200	.0160	2.13	.1150	.0020	.2425	4.2	.0180
12478	July 5	V. slight, milky.	V. slight.	0.08	14.90	.0720	.0064	1.88	.2650	.0080	.1124	4.9	.0220
12479	July 5	V. slight, milky.	Cons., rusty.	0.00	16.00	.0194	.0090	2.13	.4000	.0012	.0269	3.9	.2600

Odor, of the first sample, faintly musty; of the second, decided of gas tar; of the third, distinctly musty; and of the fourth, distinct, of fermentation. —— The samples were collected as follows: the first two from an underdrain at a man-hole in Summer Street, near Grove Street; the third, from an underdrain at the pumping station; and the last, from an underdrain near Perkins Avenue.

Microscopical Examination.

The number of organisms per cubic centimeter found in each of three samples was as follows: No. 11664, 272; No. 12477, 1,280; No. 12478, 34; No. 12479, 670. The numbers found consisted almost wholly of Crenothrix and Zoöglœa.

WATER SUPPLY OF BROOKFIELD.

The reservoir from which the supply of this town has been taken became dry about the middle of August, 1894, and is said to have remained so for about two months. During a portion of this time water for the supply of the town was pumped from the Quaboag River.

BROOKFIELD.

The advice of the State Board of Health to the town of Brookfield, relative to the use of the Quaboag River as a temporary source of water supply for the town, may be found on page 13 of this volume.

Chemical Examination of Water from South Pond, Brookfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13032	Sept 26.	Slight.	Slight.	0.02	2.25	0.45	.0000	.0110	.0098	.0012	.21	.0000	.0000	.0962	0.8

Odor none.—The sample was collected from South or Podunk Pond, near the surface, 250 feet from the shore, in connection with an investigation for a new water supply for Brookfield. This sample was nearly colorless, but at times, water having a high color backs into this pond from Quaboag Pond, and the character of the water in the vicinity of the outlet of South Pond is affected thereby.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 152; *Cyclotella*, 1; *Fragilaria*, 40; *Melosira*, 11; *Tabellaria*, 85. Cyanophyceæ, *Anabœna*, 3; *Microcystis*, 36. Algæ, *Protococcus*, 5. Infusoria, *Peridinium*, 7. Miscellaneous, *Zoöglœa*, 20. Total, 360.

Water Supply of Brookline.

It was noted in the annual report for 1891 that the works for obtaining water for the supply of Brookline from the ground near the Charles River at West Roxbury had been enlarged by laying a cast-iron pipe 24 inches in diameter from the pumping station along the West Roxbury bank of the river and across the river to the Dedham side. Forty-three tubular wells were connected with this pipe.

During the summer of 1894 still more extensive additions were made to the collecting system by extending the pipe above mentioned and building branches from it, and by adding more wells. At the present time the pipe has a total length, including branches, of 6,620 feet, and 178 tubular wells $2\frac{1}{2}$ inches in diameter, ranging in depth from 35 to 95 feet, are connected with it. The diameter of the pipe, including branches, ranges from 8 to 24 inches. The main pipe of the collecting system is connected with the pumps, so that it may be used as a suction pipe; and it is also connected with the pump well into which the water will flow from the present driven wells by gravity. The bottom of the pipe is about 7 feet lower than the

ordinary level of the water in the river. The pumps are placed at a low level, and the water in the ground can be drawn by them to a considerable depth below the bottom of the suction pipe.

Chemical Examination of Water from a Faucet at the Low-service Pumping Station of the Brookline Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11789	Feb. 19	None.	None.	0.00	7.95	.0020	.0010	.55	.0250	.0000	.0640	4.2	.0050
13116	Oct. 9	None.	None.	0.02	9.10	.0010	.0010	.68	.0180	.0002	.0570	4.6	.0050
13334	Nov. 19	None.	None.	0.05	9.40	.0008	.0028	.68	.0420	.0000	.0663	4.4	.0030
13529	Dec. 19	None.	None.	0.00	9.60	.0000	.0018	.68	.0380	.0000	.0500	4.9	.0010
Av.	....	....	....	0.02	9.01	.0010	.0017	.65	.0308	.0001	.0593	4.5	.0035

Odor, none; of No. 13334, becoming faintly vegetable on heating.—— The samples were collected from a faucet at the low-service pumping station, and represent a mixture of water from the filter-gallery and tubular wells.

Microscopical Examination.

No. 11789. Miscellaneous, *Zoöglœa*, 4.

No organisms were found in the remaining samples.

Chemical Examination of Water from the Filter-gallery and Tubular Wells of the Brookline Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
13184	Oct. 22	None.	None.	0.03	8.30	.0014	.0010	.58	.0300	.0000	.0592	4.2	.0050
13185	Oct. 22	None.	None.	0.01	7.70	.0014	.0012	.44	.0000	.0000	.0671	3.6	.0020
13186	Oct. 22	None.	None.	0.02	9.30	.0008	.0008	.63	.0380	.0001	.0592	4.6	.0030
Av.	....	....	....	0.02	8.43	.0012	.0010	.55	.0227	.0000	.0618	4.1	.0033

Odor, none.—— The first sample was collected from the eastern filter-gallery, the second from the western filter-gallery and the last from the driven wells.

Microscopical Examination.

No organisms.

BROOKLINE.

Chemical Examination of Water from the Covered Reservoir of the Brookline Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11788	Feb. 19	None.	None.	0.00	8.40	.0004	.0014	.55	.0270	.0000	.0720	4.2	.0050
13117	Oct. 9	None.	None.	0.02	9.30	.0000	.0020	.62	.0330	.0000	.0365	4.2	.0050
13333	Nov. 19	None.	None.	0.04	9.30	.0000	.0016	.68	.0450	.0000	.0624	4.4	.0000
13530	Dec. 19	None.	V. slight.	0.03	9.60	.0000	.0016	.66	.0400	.0000	.0554	4.9	.0000
Av.	....	....	....	0.02	9.15	.0001	.0017	.63	.0363	.0000	.0566	4.4	.0025

Odor, when cold, none. The odor of No. 13,530 became very faintly vegetable on heating. —— The samples were collected from the covered reservoir.

Microscopical Examination.

No. 11788. Fungi, *Crenothrix*, 16.
No. 13117. Fungi, *Crenothrix*, 2.
No organisms were found in the remaining samples.

Chemical Examination of Water from Charles River, opposite the Filter-gallery of the Brookline Water Works at West Roxbury.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
13183	Oct. 22	V. slight.	Slight.	0.60	5.95	2.00	.0006	.0180	.0168	.0012	.59	.0030	.0000	.5530	1.7

Odor, faintly vegetable, becoming also mouldy on heating. —— The sample was collected from the river, opposite the Brookline Water Works.

Microscopical Examination.

Diatomaceæ, *Amphiphora*, 1; *Cyclotella*, 1; *Meridion*, 3; *Navicula*, 2; *Pinnularia*, 1; *Synedra*, 5; *Tabellaria*, 1. Algæ, *Closterium*, 1; *Zoöspores*, 1. Fungi, *Crenothrix*, 30. Total, 46.

Water Supply of Cambridge.

The city of Cambridge has begun the construction of a large storage reservoir upon Hobbs Brook in Waltham, the main tributary of Stony Brook. Samples of water have been collected monthly from Hobbs Brook for analysis, beginning with July, and the results may be found on page 127.

CAMBRIDGE.

Chemical Examination of Water from Fresh Pond, Cambridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11589	Jan. 3	Slight.	Cons., green.	0.25	7.35	1.90	.0114	.0172	.0152	.0020	.64	.0200	.0014	.4251	3.2
11706	Feb. 5	Slight.	Slight.	0.30	6.70	2.10	.0084	.0174	.0142	.0032	.65	.0150	.0005	.4600	3.0
11836	Mar. 5	Slight.	Slight.	0.35	6.80	1.85	.0004	.0208	.0182	.0026	.62	.0300	.0002	.4920	3.0
11967	April 2	V. slight.	Cons., green.	0.32	6.65	1.80	.0000	.0198	.0164	.0034	.66	.0280	.0003	.4004	3.1
12140	May 2	Distinct.	Cons., green.	0.30	6.15	1.90	.0008	.0192	.0158	.0034	.64	.0200	.0002	.4520	2.7
12309	June 5	Distinct.	Cons., green.	0.30	6.15	1.85	.0010	.0228	.0194	.0034	.58	.0330	.0004	.4235	2.9
12485	July 9	Distinct, green.	Slight, green.	0.28	6.65	1.85	.0064	.0270	.0198	.0072	.63	.0100	.0006	.4543	2.7
12671	Aug. 7	V. slight.	Slight.	0.23	6.65	1.90	.0016	.0188	.0166	.0022	.60	.0030	.0006	.3696	2.9
12891	Sept. 5	Slight.	Slight, green.	0.18	8.50	1.50	.0002	.0202	.0150	.0052	.67	.0225	.0005	.3388	3.1
13053	Oct. 2	Slight, green.	Slight, green.	0.20	7.00	1.50	.0012	.0182	.0150	.0032	.74	.0100	.0003	.3357	3.1
13259	Nov. 5	Slight.	Cons., green.	0.40	7.35	1.70	.0274	.0168	.0128	.0040	.78	.0150	.0008	.3542	3.6
13425	Dec. 4	Slight.	Cons., light green.	0.50	7.75	1.85	.0164	.0204	.0154	.0050	.71	.0130	.0022	.3657	3.5
Av.	....	....	....	0.30	6.98	1.81	.0063	.0199	.0162	.0037	.66	.0183	.0007	.4059	3.1

Averages by Years.

–	1887*	–	–	0.04	17.32	1.94	.0105	.0180	–	–	2.11	.0266	–	–	–
–	1888	–	–	0.17	11.11	1.79	.0132	.0206	–	–	1.10	.0261	.0007	–	–
–	1889	–	–	0.11	9.86	1.83	.0145	.0220	.0170	.0050	0.90	.0334	.0008	–	–
–	1890	–	–	0.11	8.87	1.41	.0098	.0221	.0168	.0053	0.83	.0303	.0004	–	4.1
–	1891	–	–	0.15	7.94	1.80	.0095	.0235	.0162	.0073	0.75	.0333	.0004	–	3.8
–	1892	–	–	0.16	7.23	1.57	.0086	.0210	.0161	.0049	0.67	.0249	.0003	–	3.4
–	1893	–	–	0.27	6.66	1.82	.0106	.0202	.0165	.0037	0.58	.0285	.0006	.4043	3.2
–	1894	–	–	0.30	6.98	1.81	.0063	.0199	.0162	.0037	0.66	.0183	.0007	.4059	3.1

* June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable; on heating, the odor generally becomes stronger and unpleasant or grassy. —— The samples were collected from the pump well at the pumping station. For a record of heights of water in this pond at times when samples of water were collected for analysis, see page 127.

CAMBRIDGE.

Microscopical Examination of Water from Fresh Pond, Cambridge.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	5	6	3	3	6	9	7	8	2	7	5
Number of sample,	11589	11706	11836	11967	12140	12309	12485	12671	12891	13053	13259	13425
PLANTS.												
Diatomaceæ,	**2,911**	**689**	**99**	**1,007**	**2,355**	**670**	**92**	**27**	**76**	**142**	**457**	**2,156**
Asterionella,	640	11	3	60	420	13	0	0	0	16	98	940
Cyclotella,	210	84	64	36	96	136	36	4	12	0	2	0
Fragilaria,	43	24	10	27	35	0	29	0	57	49	60	20
Melosira,	400	8	8	680	460	38	0	22	7	16	202	640
Stephanodiscus,	38	2	0	70	44	2	0	1	0	0	56	216
Synedra,	0	0	0	pr.	100	1	15	0	0	60	3	44
Tabellaria,	1,580	560	14	134	1,200	480	12	0	0	1	36	296
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**14**	**46**	**20**	**10**	**113**	**5**	**14**
Anabæna,	0	0	0	0	0	14	41	9	8	0	5	0
Aphanocapsa,	0	0	0	0	0	0	0	0	1	100	0	0
Chroöcoccus,	0	0	0	0	0	0	0	8	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	5	3	1	0	0	0
Oscillaria,	0	0	0	0	0	0	0	0	0	13	0	14
Algæ,	**22**	**6**	**2**	**5**	**389**	**1,174**	**821**	**41**	**1**	**17**	**4**	**87**
Botrycoccus,	0	0	0	0	0	0	8	0	0	0	0	0
Closterium,	pr.	1	1	pr.	0	2	0	1	0	10	0	28
Ophiocytium,	pr.	2	0	0	5	0	16	0	0	0	0	0
Pandorina,	0	0	0	0	0	0	0	0	0	0	4	56
Protococcus,	6	0	0	3	378	240	780	40	0	0	0	0
Raphidium,	0	0	0	0	0	0	14	0	0	0	0	2
Scenedesmus,	pr.	0	pr.	1	3	0	0	0	0	1	0	0
Staurastrum,	16	3	1	1	3	252	3	0	1	6	0	1
Tetraspora,	0	0	0	0	0	680	0	0	0	0	0	0
Fungi, Crenothrix,	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**13**	**0**
ANIMALS.												
Infusoria,	**18**	**35**	**43**	**151**	**53**	**7**	**2**	**0**	**2**	**1**	**6**	**6**
Dinobryon,	0	0	0	4	0	0	0	0	0	0	0	0
Dinobryon cases,	0	0	1	140	0	0	0	0	0	0	0	0
Mallomonas,	0	0	0	0	1	0	0	0	0	0	1	1
Monas,	0	1	0	0	0	0	0	0	0	0	0	1
Peridinium,	0	32	22	pr.	0	2	0	0	0	1	3	0
Trachelomonas,	18	2	20	1	52	5	2	0	2	0	2	4
Vorticella,	0	0	0	4	0	0	0	0	0	0	0	0
Vorticella stems,	0	0	0	2	0	0	0	0	0	0	0	0
Vermes, Anurea,	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**
Crustacea, Cyclops,	**.01**	**0**	**.05**	**.01**	**0**	**.01**	**.07**	**0**	**0**	**0**	**0**	**.02**
Miscellaneous,	**.01**	**64**	**.01**	**240**	**48**	**15**	**15**	**52**	**400**	**112**	**0**	**.02**
Acarina,	.01	.03	.01	0	0	0	0	0	0	0	0	.02
Zoöglœa,	pr.	64	0	240	48	15	15	52	400	112	0	0
TOTAL,	2,951	794	144	1,408	2,845	1,880	976	141	489	385	485	2,264

CAMBRIDGE.

Chemical Examination of Water from Stony Brook Storage Reservoir, Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11583	Jan. 2	V. slight.	V. slight.	0.80	6.55	2.60	.0006	.0192	.0180	.0012	.41	.0430	.0001	.7995	2.3
11741	Feb. 12	V. slight.	V. slight.	0.75	6.50	2.10	.0008	.0164	.0146	.0018	.48	.0350	.0001	.6656	2.3
11858	Mar. 7	Slight.	Slight.	0.68	5.60	1.85	.0032	.0206	.0186	.0020	.43	.0230	.0001	.7000	2.1
11986	Apr. 2	V. slight	Slight.	0.80	5.50	2.35	.0004	.0210	.0186	.0024	.39	.0150	.0001	.7045	1.7
12142	May 2	Slight.	Slight.	0.90	4.75	2.00	.0008	.0230	.0194	.0036	.46	.0100	.0001	.8240	1.7
12317	June 5	V. slight.	Slight.	1.05	5.30	2.25	.0036	.0272	.0248	.0024	.39	.0150	.0000	.8200	2.1
12486	July 9	Distinct, green.	V. slight, green.	0.80	5.05	1.80	.0014	.0266	.0236	.0030	.47	.0030	.0002	.5929	2.1
12730	Aug. 13	Slight.	Slight.	0.58	5.60	1.90	.0014	.0222	.0206	.0016	.42	.0000	.0001	.5197	1.9
12896	Sept. 5	Distinct, green.	Slight, green.	0.58	4.90	1.65	.0036	.0194	.0178	.0016	.44	.0000	.0002	.5005	2.2
13071	Oct. 3	Slight.	Slight.	0.48	5.25	2.15	.0022	.0210	.0192	.0018	.52	.0000	.0000	.4898	2.3
13268	Nov. 7	Slight.	Cons., green.	0.65	5.95	1.85	.0036	.0210	.0176	.0034	.59	.0268	.0001	.4928	2.3
13434	Dec. 4	V. slight.	Slight.	0.65	6.40	1.90	.0000	.0156	.0144	.0012	.54	.0380	.0001	.5967	2.7
Av.	....	....	....	0.73	5.61	2.03	.0018	.0211	.0189	.0022	.46	.0174	.0001	.6422	2.1

Averages by Years.

-	1887*	-	-	0.81	6.21	1.82	.0049	.0347	-	-	.43	.0035	-	-	-
-	1888	-	-	0.78	5.15	1.93	.0031	.0285	-	-	.34	.0169	.0002	-	-
-	1889	-	-	0.87	4.59	1.47	.0032	.0280	.0249	.0031	.38	.0162	.0003	-	-
-	1890	-	-	0.61	5.86	2.02	.0016	.0222	.0182	.0040	.37	.0208	.0002	-	2.3
-	1891	-	-	0.56	4.99	1.86	.0016	.0213	.0183	.0030	.34	.0163	.0001	-	1.9
-	1892	-	-	0.72	5.43	1.79	.0015	.0241	.0202	.0039	.37	.0208	.0001	-	2.2
-	1893	-	-	0.66	5.32	1.97	.0020	.0235	.0196	.0039	.44	.0208	.0001	.5956	2.1
-	1894	-	-	0.73	5.61	2.03	.0018	.0211	.0189	.0022	.46	.0174	.0001	.6422	2.1

* June to November.

NOTE to analyses of 1894: Odor, vegetable; on one occasion, mouldy. On heating, the odor sometimes becomes stronger. —— The samples were collected from the reservoir, near the surface at the dam. For heights of water in this reservoir at times when samples of water were collected for analysis, see page 127.

CAMBRIDGE.

Microscopical Examination of Water from Stony Brook Storage Reservoir, Waltham.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	13	8	4	3	6	10	14	8	3	8	6
Number of sample,	11583	11741	11858	11986	12142	12317	12486	12730	12896	13071	13268	13434
PLANTS.												
Diatomaceæ,	**3**	**6**	**9**	**25**	**82**	**213**	**904**	**12**	**462**	**81**	**379**	**30**
Asterionella,	0	1	0	6	0	90	3	0	248	0	25	6
Cyclotella,	0	0	0	2	2	2	36	12	7	9	9	0
Diatoma,	0	0	pr.	0	0	1	0	0	8	0	0	1
Melosira,	0	0	0	3	46	0	0	0	0	0	0	0
Meridion,	pr.	0	5	pr.	0	0	0	0	0	0	0	3
Synedra,	3	5	4	5	18	8	840	0	188	1	1	4
Tabellaria,	0	0	0	9	16	112	25	0	11	71	344	16
Cyanophyceæ,	**0**	**1**	**0**	**0**	**0**	**0**	**23**	**14**	**60**	**72**	**0**	**0**
Anabæna,	0	0	0	0	0	0	13	6	60	72	0	0
Cœlosphærium,	0	1	0	0	0	0	10	8	0	0	0	0
Algæ,	**0**	**0**	**0**	**0**	**0**	**9**	**634**	**150**	**10**	**28**	**1**	**0**
Arthrodesmus,	0	0	0	0	0	0	20	0	3	0	0	0
Chlorococcus,	0	0	0	0	0	1	90	0	0	0	0	0
Closterium,	0	0	0	0	0	0	1	3	4	28	1	0
Protococcus,	0	0	0	0	0	8	520	147	0	0	0	0
Staurastrum,	0	0	0	0	0	0	3	0	3	0	0	0
Fungi. Crenothrix,	**0**	**1**	**28**	**1**	**32**	**1**	**1**	**2**	**3**	**1**	**2**	**0**
ANIMALS												
Rhizopoda. Actinophrys,	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
Infusoria,	**0**	**0**	**0**	**0**	**51**	**77**	**58**	**5**	**164**	**9**	**0**	**0**
Ceratium,	0	0	0	0	0	0	0	3	0	0	0	0
Ciliated infusorian,	0	0	0	0	0	0	0	0	0	4	0	0
Dinobryon,	0	0	0	0	0	20	3	0	0	0	0	0
Dinobryon cases,	0	0	0	0	50	54	11	0	164	0	0	0
Euglena,	0	0	0	0	1	0	0	0	0	2	0	0
Mallomonas,	0	0	0	0	0	3	0	0	0	1	0	0
Peridinium,	0	0	0	0	0	0	38	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	2	0	2	0	0
Vorticella,	0	0	0	0	0	0	6	0	0	0	0	0
Vermes,	**0**	**0**	**0**	**0**	**2**	**2**	**0**	**2**	**0**	**0**	**0**	**0**
Polyarthra,	0	0	0	0	0	2	0	0	0	0	0	0
Rotifer,	0	0	0	0	2	pr.	0	2	0	0	0	0
Miscellaneous Zoöglœa,	pr.	14	26	0	144	0	0	52	56	0	0	0
TOTAL,	3	22	63	27	311	302	1,620	237	755	191	383	30

CAMBRIDGE.

Chemical Examination of Water from Hobbs Brook, at Winter Street, Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved	Albuminoid. Sus-pended		Nitrates.	Nitrites.		
	1894.														
12357	June 12	Slight.	Cons., brown.	1.00	6.30	1.80	.0000	.0242	.0228	.0014	.39	.0120	.0001	.6907	1.9
12547	July 16	V. slight.	Slight.	0.30	5.00	1.40	.0014	.0146	.0132	.0014	.50	.0080	.0004	.3326	2.2
12751	Aug. 14	Slight.	Slight, green.	0.23	5.45	0.95	.0014	.0140	.0134	.0006	.45	.0100	.0001	.2348	2.3
12877	Sept. 4	V. slight.	Slight.	0.23	4.75	1.25	.0010	.0162	.0146	.0016	.57	.0000	.0002	.2387	2.1
13105	Oct. 9	V. slight.	V. slight.	0.30	6.00	1.40	.0000	.0126	.0116	.0010	.62	.0080	.0000	.2774	2.3
13272	Nov. 6	Slight.	Slight.	1.30	10.85	3.80	.0006	.0380	.0342	.0038	.68	.0500	.0000	1.2974	3.8
13509	Dec. 18	V. slight	Slight.	1.20	8.40	2.90	.0008	.0302	.0278	.0024	.49	.0480	.0000	1.0318	3.0
Av.	....	....	....	0.65	6.68	1.93	.0007	.0214	.0197	.0017	.53	.0194	.0001	.5862	2.5

Odor, generally distinctly vegetable, sometimes also mouldy; on one occasion none. —— The samples were collected from the brook.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 143.

Table showing Heights of Water in Fresh Pond and in Stony Brook Storage Reservoir on the Dates when Samples of Water were collected for Analysis.

[Heights are in feet above Cambridge city base.]

Fresh Pond. High Water, 16.85. Date.	Height of Water.	Stony Brook Reservoir. Rollway, 81.00. Date.	Height of Water.
1894.		1894.	
Jan. 3, ...	13.42	Jan. 2, ...	81.18
Feb. 5, ...	15.15	Feb. 12, ...	81.25
Mar. 5, ...	16.08	Mar. 7, ...	82.24
April 2, ...	16.64	April 2, ...	81.27
May 2, ...	16.79	May 2, ...	81.22
June 5, ...	16.70	June 5, ...	81.27
July 9, ...	16.32	July 9, ...	75.16
Aug. 7, ...	14.01	Aug. 13, ...	74.44
Sept. 5, ...	11.63	Sept. 5, ...	73.96
Oct. 2, ...	10.78	Oct. 3, ...	71.16
Nov. 5, ...	11.77	Nov. 7, ...	69.56
Dec. 4, ...	12.56	Dec. 4, ...	75.00

CANTON.

Water Supply of Canton.

Early in 1894 the sources of supply of the town of Canton were enlarged by the construction of a well at Henry Springs. The well is located near the line between Canton and Stoughton, east of Washington Street and north of York Street. It is circular in form, 40 feet in diameter and 23 feet deep, and is provided with a roof. The material into which the well is sunk is gravel, overlaid with quicksand. The walls of the well are of brick, laid in cement mortar, with a bottom course of granite 3 feet wide. Openings were left in the brickwork just above the granite foundation to admit water to the well. The lower 12 feet of the wall is 20 inches in thickness, and the portion above this 16 inches in thickness to the surface of the ground, where the thickness is reduced to 12 inches, the walls being carried to a height of 3 feet above the ground. The new well is connected with the well at Springdale by a cast-iron pipe 8,960 feet in length, having a total fall from the bottom of the new well to the bottom of the well at Springdale of 59 feet. Provision has been made for taking into this pipe in the future water from other sources in its vicinity, if found desirable. Water was first used from the new well June 15, 1894.

Chemical Examination of Water from a Faucet at the Pumping Station of the Canton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12976	Sept. 18	None.	None.	0.03	5.50	.0000	.0014	.41	.0220	.0000	.0038	1.4	.0050

Odor, none. —— The sample was collected from a faucet at the pumping station, while pumping.

Microscopical Examination.

No organisms.

Water Supply of Chelsea.

(See *Boston, Mystic Works.*)

WATER SUPPLY OF CHESTER.

Chemical Examination of Water from the Austin Brook Reservoir of the Chester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
12462	July 2	None.	V. slight.	0.05	3.40	0.95	.0016	.0042	.0036	.0006	.11	.0100	.0000	.1386	1.6

Odor, faintly vegetable. —— The sample was collected from the reservoir, at the dam.

Microscopical Examination.

Fungi, *Crenothrix*, 5. Miscellaneous, *Zoöglœa*, 12. Total, 17.

WATER SUPPLY OF CHICOPEE.

Chemical Examination of Water from Cooley Brook and the Cooley Brook Reservoir, Chicopee.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11673	Jan. 23	V. slight.	Cons.	0.30	4.05	0.95	.0004	.0034	.0022	.0012	.11	.0050	.0000	.2607	1.3
11933	Mar. 21	V. slight.	Slight.	1.00	3.70	1.25	.0006	.0112	.0088	.0024	.08	.0070	.0000	.7426	0.5
12282	May 23	Slight.	Cons.	1.00	4.80	1.55	.0030	.0138	.0110	.0028	.08	.0050	.0000	.7254	1.3
12639	July 30	Slight.	Slight, brown.	0.30	4.15	0.80	.0022	.0074	.0058	.0016	.11	.0040	.0001	.2464	1.2
13025	Sept. 25	V. slight.	Slight.	0.30	4.25	0.80	.0010	.0082	.0068	.0014	.10	.0040	.0000	.1886	1.1
13373	Nov. 26	Slight.	Slight.	0.60	4.00	1.10	.0014	.0108	.0084	.0024	.13	.0000	.0000	.4510	1.4
Av.	....	....	....	0.58	4.16	1.08	.0014	.0091	.0072	.0019	.10	.0042	.0000	.4358	1.1

Odor, generally vegetable, on one occasion none. On heating, the odor generally becomes stronger. —— The samples were collected as follows: No. 11673, from Cooley Brook, 200 feet below the dam; No. 11933, from Cooley Brook, 500 feet above the reservoir; and the remaining samples from Cooley Brook Reservoir.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 75. The highest number (192) was found in May, and consisted chiefly of Zoöglœa.

CHICOPEE.

Chemical Examination of Water from Morton Brook Reservoir, Chicopee.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11674	Jan. 23	Slight.	Cons.	0.02	3.60	0.55	.0012	.0008	.0006	.0002	.13	.0120	.0000	.0276	1.1
11934	Mar. 21	None.	V. slight.	0.01	3.55	0.50	.0002	.0022	.0016	.0006	.11	.0180	.0000	.0790	0.6
12283	May 23	V. slight.	Slight.	0.02	4.35	0.80	.0014	.0050	.0036	.0014	.12	.0180	.0000	.0952	1.3
12640	July 30	V. slight.	Slight.	0.02	3.85	0.60	.0000	.0016	.0010	.0006	.12	.0050	.0000	.0462	0.8
13024	Sept. 25	V. slight.	Cons., sand.	0.08	3.60	0.40	.0000	.0030	.0024	.0006	.13	.0060	.0000	.0346	1.1
13374	Nov. 26	None.	Slight.	0.05	3.60	0.70	.0002	.0052	.0044	.0008	.13	.0030	.0000	.0738	1.4
Av.	....	....	....	0.03	3.76	0.59	.0005	.0030	.0023	.0007	.12	.0103	.0000	.0594	1.1

Odor of No. 11674, faintly vegetable; of No. 13024, very faintly vegetable; of the other samples, none. The odor of No. 12640 became very faintly vegetable on heating. —— The samples were collected from the reservoir.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 13, the highest number (39) being found in the September sample.

Chemical Examination of Water from the Receiving Basin at the Pumping Station of the Chicopee Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12601	July 23	V. slight.	Slight.	0.35	4.50	1.35	.0008	.0080	.0060	.0020	.12	.0050	.0001	.2849	1.1

Odor, faintly vegetable. —— The sample was collected from the receiving basin at the Cooley Brook pumping station, and was composed of water from both Cooley and Morton brooks.

Microscopical Examination.

Diatomaceæ, *Navicula*, 1; *Pinnularia*, 1. Fungi, *Crenothrix*, 56. Miscellaneous, *Zoōglœa*, 2. Total, 60.

Water Supply of Cohasset. — Cohasset Water Company.

The results of the examinations of samples of water from the driven wells of this company made in 1894 show a large increase in the amount of iron in the water, the presence of which was noted in the last annual report. As there stated, the determinations of turbidity, sediment and color in a sample of water of this class

COHASSET.

may vary with the length of time that the water has been exposed to the air after it has been drawn from the ground, since they are dependent upon the amount of iron which has been thereby oxidized and converted into an insoluble form. The results of these determinations should therefore not be interpreted as indicating the variation in the quality of this water from month to month, but they are nevertheless of value as indicating a condition which the water may assume.

Chemical Examination of Water from the Tubular Wells of the Cohasset Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11629	Jan. 11	Distinct, milky.	None.	0.15	20.50	.0008	.0016	1.65	.0200	.0000	.0195	10.0	.0620
11688	Feb. 2	Distinct, milky.	V. slight	0.00	19.40	.0000	.0010	1.85	.0200	.0000	.0592	10.0	.0300
11851	Mar. 6	Distinct, milky.	None.	0.15	19.00	.0000	.0020	1.98	.0130	.0000	.0424	9.3	.0500
12037	Apr. 12	Slight.	Slight.	0.30	20.10	.0006	.0008	1.79	.0150	.0000	.0240	9.6	.1100
12178	May 9	Slight, milky.	V. slight.	0.08	14.50	.0000	.0010	1.78	.0250	.0000	.0640	6.6	.0250
12342	June 11	Distinct, milky.	V. slight.	0.20	15.40	.0006	.0016	1.76	.0180	.0000	.0323	8.0	.0760
12474	July 5	Distinct, milky.	V. slight, rusty.	0.20	17.90	.0000	.0018	1.74	.0070	.0000	.0231	8.6	.0600
12739	Aug. 13	Decided, milky.	Slight, rusty	0.23	17.30	.0010	.0010	1.67	.0070	.0000	.0077	7.0	.0550
12920	Sept. 10	Distinct, milky.	V. slight.	0.20	15.10	.0010	.0004	1.65	.0300	.0000	.0000	7.7	.0500
13098	Oct. 8	Distinct, milky.	V. slight.	0.10	15.30	.0000	.0010	1.77	.0150	.0000	.0114	6.4	.0700
13270	Nov. 7	Distinct, milky.	Slight, rusty.	0.30	17.20	.0006	.0038	1.82	.0500	.0000	.0246	8.4	.1250
13479	Dec. 13	Decided, milky.	V slight.	0.10	23.60	.0002	.0030	1.83	.0250	.0000	.0231	9.6	.1780
Av.	....	....	....	0.17	17.94	.0004	.0016	1.77	.0204	.0000	.0276	8.4	.0743

Averages by Years.

–	1887*	–	–	0.00	15.21	.0005	.0016	1.69	.0196	–	–	–	–
–	1888	–	–	0.01	15.20	.0001	.0021	1.50	.0311	.0003	–	–	–
–	1889†	–	–	0.00	11.64	.0001	.0022	1.46	.0230	.0002	–	–	–
–	1890‡	–	–	0.00	–	.0000	.0048	1.48	.0150	.0003	–	–	–
–	1893	–	–	0.16	17.14	.0001	.0007	1.64	.0263	.0001	.0415	8.6	.0451
–	1894	–	–	0.17	17.94	.0004	.0016	1.77	.0204	.0000	.0276	8.4	.0743

* June to December. † January to May. ‡ February.

NOTE to analyses of 1894: Odor of No. 12037, decided; of No. 12739, faint; of the other samples none. On heating, the odor of the last sample was very faintly vegetable. The samples were collected from a faucet at the pumping station, while pumping.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 220, consisting almost wholly of Crenothrix, the highest number (616) being found in the November sample.

COHASSET.

Chemical Examination of Water from a Tubular Test Well in Cohasset.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12962	Sept. 17	Slight.	Slight.	0.05	17.80	.0006	.0004	3.12	.4000	.0015	.0231	4.3	.0300

Odor, none. —— The sample was collected from a tubular test well located about 1,000 feet south-east of the pumping station of the Cohasset Water Company, and about 500 feet south of the railroad.

Microscopical Examination.

Fungi, *Crenothrix*, 11.

Water Supply of Concord.

Chemical Examination of Water from Sandy Pond, Lincoln.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11643	Jan. 16	None.	V. slight.	0.01	2.50	0.85	.0022	.0144	.0130	.0014	.33	.0030	.0000	.1209	1.3
11748	Feb. 12	V. slight.	V. slight.	0.00	1.95	0.60	.0026	.0180	.0158	.0022	.24	.0030	.0000	.0864	0.2
12042	Apr. 16	V. slight.	V. slight.	0.05	2.60	1.00	.0000	.0074	.0062	.0012	.25	.0050	.0000	.1664	0.6
Av.	......	....	....	0.02	2.35	0.82	.0016	.0133	.0117	.0016	.27	.0037	.0000	.1246	.07

Iron, .0028. Odor of the first sample, distinctly vegetable and grassy; of the second, faintly vegetable and earthy, becoming stronger and grassy on heating; of the last sample, very faintly vegetable, becoming distinctly oily on heating. —— The first and second samples were collected from the pond and the last from a faucet on Hubbard Street.

CONCORD.

Microscopical Examination of Water from Sandy Pond, Lincoln.

[Number of organisms per cubic centimeter.]

	1894.		
	January.	February.	April.
Day of examination,	18	14	17
Number of sample,	11643	11748	12042
PLANTS.			
Diatomaceæ,	**2**	**pr.**	**28**
Asterionella,	0	0	18
Cyclotella,	0	0	8
Melosira,	2	0	0
Synedra,	0	pr.	2
Algæ,	**5**	**0**	**28**
Chlorococcus,	0	0	6
Protococcus,	5	0	0
Raphidium,	0	0	4
Tetraspora,	0	0	18
ANIMALS.			
Infusoria,	**66**	**18**	**156**
Dinobryon,	0	14	46
Dinobryon cases,	66	4	110
Miscellaneous, Zoöglœa,	**3**	**0**	**0**
TOTAL,	76	18	212

TUBULAR WELLS AT THE MASSACHUSETTS REFORMATORY, CONCORD.

These wells were formerly used as a source of supply by the Massachusetts Reformatory, but no water has been pumped from them for several years. Pumping was begun on April 18, 1894, and about a million gallons are said to have been pumped from them previous to collecting a sample of water for analysis, the results of which are given below. There are 32 wells in all, 1½ inches in diameter and from 40 to 60 feet deep, sunk in a sandy tract of land between the walls surrounding the Reformatory and the Assabet River. Sewage is disposed of by filtration through this sandy land on both sides and back of the wells and within a few hundred feet of them. It will be seen from an examination of the analysis that the water of these wells is a strong and fairly well purified sewage effluent.

CONCORD.

Chemical Examination of Water from the Tubular Wells at the Massachusetts Reformatory, Concord.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12120	Apr. 30	None.	V. slight.	0.04	33.00	.1200	.0030	6.62	1.4250	.0090	.0577	8.0	.0180

Averages by Years.

-	1887*	-	-	0.00	17.51	.0011	.0020	2.55	.8437	-	-	-	-
-	1888†	-	-	0.00	22.31	.0572	.0073	4.43	.7550	.0019	-	-	-
-	1889‡	-	-	0.00	20.71	.0039	.0028	3.30	1.1650	.0008	-	-	-
-	1894§	-	-	0.04	33.00	.1200	.0030	6.62	1.4250	.0090	.0577	8.0	.0180

* July to October, four samples.
† May and June, four samples.
‡ January and February, five samples.
§ April.

NOTE to analysis of 1894: The sample had a distinct odor of coal gas, which disappeared on heating. —— The sample was collected from a faucet on the pump drawing water from the wells.

Microscopical Examination.

Fungi, *Crenothrix*, 1.

WATER SUPPLY OF COTTAGE CITY. — COTTAGE CITY WATER COMPANY.

Chemical Examination of Water from the Springs of the Cottage City Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12616	July 25	None.	V. slight.	0.04	3.70	.0000	.0004	.94	.0080	.0000	.0115	0.6	.0080
12921	Sept. 11	None.	None.	0.00	3.50	.0000	.0000	.82	.0110	.0000	.0000	0.8	.0050

Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No. 12616. Diatomaceæ, *Synedra*, 1. *Scenedesmus*, 1. Total, 2.
No. 12921. No organisms.

Water Supply of Dalton Fire District, Dalton.

In 1894 a new reservoir was built on Egypt Brook, just above the old one. The average depth of the new reservoir is 8 feet, and its capacity is 12,000,000 gallons.

Water Supply of Danvers.

Chemical Examination of Water from Middleton Pond, Middleton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
12828	1894. Aug. 27	V. slight.	Slight.	0.55	4.90	1.90	.0000	.0152	.0140	.0012	.40	.0070	.0000	.4928	1.7

Odor, faintly vegetable, becoming stronger on heating. —— The sample was collected from a faucet.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 2; *Cyclotella*, 4; *Synedra*, 2; *Tabellaria*, 172. Cyanophyceæ, *Anabæna*, 5; *Chroöcoccus*, 16. Fungi, *Crenothrix*, 2. Miscellaneous, *Zoöglœa*, 48. Total, 251.

Chemical Examination of Water from Swan's Pond, North Reading.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
13177	1894. Oct. 22.	Slight.	Cons.	0.18	3.40	1.40	.0004	.0150	.0136	.0014	.37	.0000	.0000	.4029	1.1

Odor, none, becoming faintly vegetable on heating. —— The sample was collected from the pond.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 8; *Cyclotella*, 2; *Navicula*, 1; *Tabellaria*, 30. Algæ, *Closterium*, 1; *Zoöspores*, 1. Fungi, *Crenothrix*, 4. Infusoria, *Dinobryon*, 30; *Dinobryon cases*, 4; *Mallomonas*, 2. Crustacea, *Cyclops*, .01. Miscellaneous, *Zoöglœa*, 4. Total, 87.

DEDHAM.

Water Supply of Dedham. — Dedham Water Company.

Chemical Examination of Water from the Well of the Dedham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11791	Feb. 20	None.	None.	0.00	9.20	.0000	.0020	.88	.1750	.0000	.0320	4.3	.0000
12043	Apr. 16	None.	None.	0.00	9.70	.0000	.0012	.89	.2000	.0000	.0320	4.0	.0010
12414	June 21	None.	None.	0.00	10.70	.0000	.0012	.96	.2100	.0000	.0262	4.2	.0000
12773	Aug. 17	None.	None.	0.05	11.00	.0000	.0018	.58	.1600	.0000	.0385	3.6	.0040
13148	Oct. 17	None.	None.	0.00	11.00	.0000	.0010	.99	.3000	.0000	.0434	4.2	.0020
13534	Dec. 20	None.	None.	0.02	9.50	.0000	.0030	.85	.1600	.0001	.0038	3.9	.0010
Av.	....	....	....	0.01	10.18	.0000	.0017	.86	.2008	.0000	.0293	4.0	.0013

Averages by Years.

-	1887*	-	-	0.00	10.97	.0002	.0012	.97	.2690	-	-	-	-
-	1888†	-	-	0.00	10.38	.0002	.0011	.93	.2810	.0000	-	-	-
-	1889‡	-	-	0.00	9.15	.0000	.0020	.93	.1700	.0000	-	-	-
-	1892	-	-	0.01	10.80	.0002	.0054	.93	.2962	.0001	-	4.4	.0108
-	1893	-	-	0.01	10.49	.0014	.0073	.91	.2375	.0001	.1209	4.3	.0139
-	1894	-	-	0.01	10.18	.0000	.0017	.86	.2008	.0000	.0293	4.0	.0013

* June to December. † January to May. ‡ April.

Note to analyses of 1894: Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination of Water from the Well of the Dedham Water Company.

[Number of organisms per cubic centimeter.]

	1894.					
	February.	April.	June.	August.	October.	December.
Day of examination,	22	17	23	18	18	22
Number of sample,	11791	12043	12414	12773	13148	13534
PLANTS.						
Diatomaceæ,	0	800	17	0	3	0
Asterionella,	0	760	5	0	1	0
Fragilaria,	0	0	4	0	0	0
Synedra,	0	40	8	0	2	0
Total,	0	800	17	0	3	0

Water Supply of Dudley.

The advice of the State Board of Health to D. W. Crosby of Webster, relative to extending the water pipes of the Webster water supply into a village in the town of Dudley, may be found on page 14 of this volume.

Water Supply of Easthampton.

Chemical Examination of Water from the Easthampton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11930	Mar.21	Slight.	Slight.	0.30	3.40	1.00	.0004	.0096	.0072	.0024	.11	.0030	.0000	.3816	0.6
12425	June23	Distinct.	Slight.	0.25	4.20	0.75	.0000	.0052	.0044	.0008	.10	.0050	.0000	.1756	1.6
13040	Sept.27	None.	V. slight.	0.32	4.25	1.00	.0004	.0066	.0056	.0010	.16	.0020	.0000	.3240	4.7
Av.	....	....	....	0.29	3.95	0.92	.0003	.0071	.0057	.0014	.12	.0033	.0000	.2937	2.3

Odor of the first sample, very faintly vegetable; of the second, faintly vegetable; of the third, very faint. The odor of all three samples was stronger on heating. —— The first sample was collected from a well at the pumping station, and the others from a faucet.

Microscopical Examination

The number of organisms per cubic centimeter found in each of these samples was as follows: No. 11930, 33; No. 12425, 94; No. 13040, 23.

Water Supply of North Easton Village District, Easton.

Chemical Examination of Water from the Well of the North Easton Village District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12375	June 13	None.	None.	0.0	3.60	.0000	.0008	.49	.0250	.0000	.0154	1.1	.0000
12951	Sept. 12	None.	None.	0.0	4.10	.0004	.0004	.48	.0100	.0000	.0077	1.3	.0050

Odor, none. —— The samples were collected from the well.

Microscopical Examination.

No organisms.

Essex.

In connection with an investigation for an additional water supply for the city of Gloucester, analyses were made of samples of water collected from the Chebacco Lakes, so-called, in Essex, Hamilton and Wenham, and the results are given below.

Chemical Examination of Water from Chebacco Lake in Essex and Hamilton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11902	Mar. 15	V. slight.	V. slight.	1.00	4.85	1.90	.0010	.0230	.0206	.0024	.87	.0000	.0000	.8680	0.6
12635	July 30	Slight.	Slight.	1.00	5.65	2.25	.0006	.0190	.0166	.0024	.95	.0000	.0000	.7623	0.8
12838	Aug. 27	V. slight.	Slight.	0.75	5.00	2.00	.0004	.0196	.0182	.0014	.96	.0030	.0000	.6160	0.9
13017	Sept. 22	Slight.	Slight.	0.65	4.70	1.55	.0014	.0180	.0166	.0014	.98	.0000	.0000	.5929	0.8
13249	Oct. 31	V. slight.	Slight.	0.50	4.80	2.00	.0008	.0168	.0140	.0028	1.03	.0000	.0000	.5467	1.1
13390	Nov. 26	V. slight.	Cons.	0.65	5.00	2.05	.0014	.0192	.0176	.0016	.96	.0000	.0000	.7503	0.9
13577	Dec. 31	Slight.	Slight.	1.00	6.55	2.65	.0004	.0238	.0224	.0014	1.58	.0050	.0000	.9779	1.6
Av.	....	....	....	0.79	5.22	2.06	.0009	.0199	.0180	.0019	1.05	.0011	.0000	.7306	1.0

Odor, vegetable. —— The samples were collected from the lake, near the northerly end.

Microscopical Examination of Water from Chebacco Lake in Essex and Hamilton.

[Number of organisms per cubic centimeter.]

	1894.						1895.
	Mar.	Aug.	Aug.	Sept.	Nov.	Nov.	Jan.
Day of examination, ...	17	1	29	26	8	28	2
Number of sample, ...	11902	12635	12838	13017	13249	13390	13577
PLANTS.							
Diatomaceæ, ...	10	30	13	0	10	16	17
Asterionella, ...	4	0	0	0	0	0	0
Cyclotella, ...	3	0	0	0	4	0	0
Melosira, ...	0	0	5	0	0	10	0
Meridion, ...	1	0	0	0	0	0	2
Synedra, ...	2	0	3	0	5	6	14
Tabellaria, ...	0	30	5	0	1	0	1
Cyanophyceæ, Merismopedia, . .	0	10	0	0	0	0	0
Fungi, Crenothrix, ...	22	0	0	0	0	3	0

ESSEX.

Microscopical Examination of Water from Chebacco Lake — Concluded.

[Number of organisms per cubic centimeter.]

	1894.						1895.
	Mar.	Aug.	Aug.	Sept.	Nov.	Nov.	Jan.
ANIMALS.							
Rhizopoda, Difflugia,	0	0	0	0	2	2	0
Infusoria,	133	59	8	0	1	1	13
Dinobryon,	104	0	0	0	0	0	0
Dinobryon cases,	26	0	0	0	0	0	0
Euglena,	0	0	0	0	0	0	2
Monas,	0	3	0	0	0	0	0
Peridinium,	3	52	7	0	0	1	11
Tintinnidium,	0	2	0	0	0	0	0
Trachelomonas,	0	2	1	0	1	0	0
Vermes,	pr.	0	0	4	0	7	0
Anurea,	0	0	0	4	0	1	0
Polyarthra,	pr.	0	0	0	0	2	0
Rotatorian ova,	pr.	0	0	0	0	4	0
Miscellaneous, Zoöglœa,	0	56	15	40	164	0	0
TOTAL,	165	155	36	44	177	29	30

Chemical Examination of Water from Round Pond, Hamilton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11903	Mar. 15	Slight.	Slight.	1.40	5.05	2.20	.0008	.0232	.0206	.0026	.76	.0000	.0000	.9440	0.8
12632	July 30	V. slight.	Slight.	1.00	4.35	2.00	.0000	.0202	.0182	.0020	.91	.0000	.0000	.8316	0.8

Odor, faintly vegetable, becoming stronger on heating. —— The samples were collected from the pond, near the outlet.

Microscopical Examination.

No. 11903. Diatomaceæ, *Asterionella*, 1; *Cyclotella*, 1; *Meridion*, 3; *Navicula*, 2; *Tabellaria*, 28. Algæ, *Staurastrum*, 1; *Zoöspores*, 6. Infusoria, *Dinobryon*, 20; *Dinobryon cases*, 4; *Monas*, 1; *Peridinium*, 6. Vermes, *Rotifer*, 1. Miscellaneous, *Acarina*, .08; *Zoöglœa*, 2. Total, 76.

No. 12632. Diatomaceæ, *Asterionella*, 10; *Cyclotella*, 3; *Diatoma*, 1; *Tabellaria*, 61. Cyanophyceæ, *Merismopedia*, 4. Algæ, *Pandorina*, 1; *Staurogenia*, 4. Fungi, *Crenothrix*, 2. Infusoria, *Dinobryon cases*, 1; *Glenodinium*, 1; *Monas*, 4; *Peridinium*, 100; *Trachelomonas*, 1. Miscellaneous, *Zoöglœa*, 80. Total, 273.

ESSEX.

Chemical Examination of Water from Gravelly Pond, Hamilton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11904	Mar. 15	None.	V. slight.	0.04	3.40	0.90	.0000	.0124	.0114	.0010	.76	.0000	.0000	.2280	0.5
12633	July 30	Slight.	Slight.	0.08	3.25	1.00	.0000	.0122	.0106	.0016	.88	.0000	.0000	.1771	0.7

Odor of the first sample, none; of the second, faintly vegetable, becoming stronger on heating.—— The samples were collected from the pond, near the outlet.

Microscopical Examination.

No. 11904. Diatomaceæ, *Cyclotella*, 1; *Synedra*, 22; *Tabellaria*, 3. Algæ, *Arthrodesmus*, 1; *Protococcus*, 6. Infusoria, *Dinobryon cases*, 26; *Peridinium*, 7. Miscellaneous, *Zoöglœa*, 16. Total, 82.

No. 12633. Diatomaceæ, *Cyclotella*, 1; *Cymbella*, 1; *Navicula*, 1. Cyanophyceæ, *Anabæna*, 6; *Chroöcoccus*, 5; *Merismopedia*, 4. Algæ, *Conferva*, 1; *Staurogenia*, 2. Infusoria, *Dinobryon cases*, 42; *Peridinium*, 40; *Phacus*, 1. Vermes, *Rotatorian ova*, 1. Miscellaneous, *Zoöglœa*, 60. Total, 165.

Chemical Examination of Water from Beck's Pond, Hamilton, and Coy's Pond, Wenham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
12631	July 30	V. slight.	Slight.	0.90	5.55	2.05	.0016	.0200	.0190	.0010	1.19	.0000	.0000	.7715	2.1
12634	July 30	Distinct.	Slight, rusty.	1.50	5.50	2.10	.0014	.0276	.0258	.0018	.93	.0020	.0000	1.0253	1.6

Odor of the first sample, faintly vegetable; of the second, decidedly mouldy.——The first sample was collected from Beck's Pond, near its outlet, and the second from Coy's Pond, 100 feet from shore.

Microscopical Examination.

No. 12631. Diatomaceæ, *Cyclotella*, 1. Cyanophyceæ, *Merismopedia*, 12. Algæ, *Chlorococcus*, 13; *Protococcus*, 30. Fungi, *Crenothrix*, 24. Infusoria, *Euglena*, 1; *Monas*, 2; *Peridinium*, 3. Miscellaneous, *Zoöglœa*, 36. Total, 122.

No. 12634. Diatomaceæ, *Cyclotella*, 1; *Synedra*, 1; *Tabellaria*, 1. Cyanophyceæ, *Anabæna*, 3. Algæ, *Chlorococcus*, 1; *Staurastrum*, 24. Fungi, *Crenothrix*, 32. Infusoria, *Ciliated infusorian*, 1; *Dinobryon cases*, 52; *Euglena*, 5; *Monas*, 2; *Peridinium*, 48; *Trachelomonas*, 24. Vermes, *Anurea*, 1; *Rotifer*, 1. Miscellaneous, *Zoöglœa*, 3. Total, 200.

ESSEX.

Chemical Examination of Water from a Tubular Well at the Cadets' Camp Ground, in Essex.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
12586	1894. July 17	None.	None.	0.0	3.50	.0000	.0000	.83	.0080	.0000	.0000	0.6	.0070

Odor, none.

Microscopical Examination.

No organisms.

Water Supply of Everett.

(See *Boston, Mystic Works.*)

Chemical Examination of Water from a Tubular Test Well in Bradley Meadow, Everett.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
13542	1894. Dec. 22	None.	None.	0.0	18.90	.0000	.0032	4.30	.9000	.0000	.0000	8.3	.0000

Odor, none. —— The sample was collected in connection with an investigation for a water supply for Everett.

Microscopical Examination.

No organisms.

FAIRHAVEN.

WATER SUPPLY OF FAIRHAVEN. — FAIRHAVEN WATER COMPANY.

Population in 1890, 2,919. The works are owned by the Fairhaven Water Company, and water was introduced about Feb. 1, 1894. The source of supply is a system of twenty-six 2½-inch tubular wells in the valley of the Nasketucket River, near the centre of the town. The wells are located on both sides and in the bed of the river, which is a very small and shallow stream, and cover an area approximately 300 feet in length in a northerly and southerly direction, by about 130 feet in width. The wells are generally about 35 feet in depth, and are in gravelly material overlaid with a stratum of clay near the surface. Pumps force the water to a covered iron tank 35 feet in diameter and 41.5 feet in height, which is supported by an iron trestle about 100 feet in height. Distributing mains are of cast iron and service pipes of lead.

Chemical Examination of Water from the Tubular Wells of the Fairhaven Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11767	Feb. 14	None.	None.	0.00	6.00	.0000	.0044	.96	.0600	.0000	.0880	1.8	.0100
11844	Mar. 5	V. slight.	None.	0.08	6.60	.0026	.0064	1.02	.1150	.0000	.0840	1.8	.0500
11963	Mar. 28	V. slight.	V. slight.	0.05	6.20	.0000	.0032	1.04	.1350	.0000	.1155	2.3	.0140
12093	Apr. 23	V. slight.	None.	0.02	6.20	.0006	.0016	1.06	.1100	.0002	.0395	1.8	.0120
12333	June 7	V. slight.	V. slight.	0.05	4.70	.0000	.0026	.94	.0780	.0008	.0693	2.1	.0260
12429	June 24	None.	None.	0.05	6.35	.0002	.0010	.93	.1100	.0004	.0855	1.7	.0110
12589	July 21	None.	None.	0.07	7.50	.0000	.0020	1.00	.0980	.0002	.0739	1.9	.0060
12985	Sept. 17	None.	None.	0.02	5.90	.0002	.0016	.96	.0630	.0001	.0539	1.4	.0000
13091	Oct. 4	None.	None.	0.02	5.40	.0000	.0010	.91	.0750	.0001	.0513	1.4	.0070
13215	Oct. 25	None.	None.	0.10	6.10	.0004	.0030	1.01	.0500	.0001	.1461	1.8	.0200
13405	Dec. 3	None.	None.	0.02	6.20	.0006	.0016	.99	.1100	.0003	.0269	1.9	.0180
Av.*	....	....	....	0.04	6.19	.0004	.0024	.98	.0903	.0002	.0698	1.8	.0138

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No. 11844. Fungi, *Crenothrix*, 3. No. 11963. Fungi, *Crenothrix*, 4. No. 13215. Fungi, *Crenothrix*, 1. No organisms were found in the remaining samples.

Water Supply of Fall River.

Chemical Examination of Water from North Watuppa Lake.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1891														
11925	Mar. 20	V. slight.	V. slight.	0.20	3.10	1.15	.0014	.0162	.0138	.0024	.53	.0050	.0000	.3792	0.5
12044	Apr. 16	Distinct.	Slight.	0.30	3.10	1.15	.0000	.0136	.0122	.0014	.54	.0030	.0000	.4064	0.6

Odor, distinctly vegetable, becoming also somewhat unpleasant on heating. —— The samples were collected from the lake.

Microscopical Examination.

No. 11925. Diatomaceæ, *Cyclotella*, 28; *Tabellaria*, 3. Infusoria, *Dinobryon*, 100; *Dinobryon cases*, 170. Total, 301.

No. 12044. Diatomaceæ, *Asterionella*, 1; *Cyclotella*, 34; *Diatoma*, 4; *Fragilaria*, 1; *Navicula*, 1; *Synedra*, 4; *Tabellaria*, 1. Algæ, *Arthrodesmus*, 1; *Chlorococcus*, 4; *Cosmarium*, 1; *Nephrocytium*, 2; *Raphidium*, 1; *Sorastrum*, 1; *Tetraspora*, 18. Infusoria, *Dinobryon*, 60; *Dinobryon cases*, 230. Miscellaneous, *Zoöglœa*, 11. Total, 375.

Water Supply of Falmouth Heights. — Falmouth Heights Water Company.

Chemical Examination of Water from the Wells of the Falmouth Heights Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1894.												
12703	Aug. 9	None.	None.	0.05	6.70	.0000	.0010	2.36	.0000	.0000	.0080	1.3	.0080

Odor, faint. —— The sample was collected from a faucet at the Craig House.

Microscopical Examination.

No organisms.

FITCHBURG.

Water Supply of Fitchburg.

Chemical Examination of Water from Scott Reservoir, Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11637	Jan. 5	Slight.	Slight.	0.15	2.65	0.85	.0020	.0236	.0202	.0034	.20	.0070	.0000	.2948	0.3
12050	Apr. 16	Slight.	Cons.	0.10	2.10	0.70	.0004	.0124	.0076	.0048	.17	.0000	.0000	.1864	0.0
12545	July 16	Decided.	Slight, yellow.	0.15	3.00	1.40	.0004	.0192	.0146	.0046	.15	.0000	.0002	.2972	0.3
13145	Oct. 16	Distinct.	Cons. green.	0.15	2.40	1.10	.0000	.0212	.0150	.0062	.20	.0000	.0000	.3357	0.3
Av.	....	....	....	0.14	2.54	1.01	.0007	.0191	.0143	.0048	.18	.0018	.0001	.2785	0.2

Averages by Years.

-	1887*	-	-	0.30	2.63	1.01	.0007	.0231	-	-	.15	.0021	-	-	-
-	1888	-	-	0.11	2.31	0.79	.0004	.0240	-	-	.13	.0040	.0001	-	-
-	1889	-	-	0.09	2.12	0.62	.0008	.0213	.0162	.0051	.13	.0030	.0001	-	-
-	1890	-	-	0.10	2.54	1.02	.0010	.0217	.0152	.0065	.13	.0059	.0001	-	0.9
-	1891	-	-	0.13	2.55	1.05	.0007	.0146	.0110	.0036	.14	.0082	.0000	-	0.6
-	1892	-	-	0.13	2.78	1.16	.0005	.0261	.0198	.0063	.18	.0089	.0000	-	0.5
-	1893	-	-	0.10	2.68	1.30	.0001	.0233	.0162	.0071	.17	.0033	.0000	.2870	0.4
-	1894	-	-	0.14	2.54	1.01	.0007	.0191	.0143	.0048	.18	.0018	.0001	.2785	0.2

* June to December.

Note to analyses of 1894: Odor, distinctly vegetable, becoming grassy or pungent on heating.—— The samples were collected from the reservoir. The heights of water in this reservoir on dates when samples of water were collected for analysis were as follows: January 5, 40 feet; April 16, 40 feet; July 16, 25 feet; October 16, 21 feet.

FITCHBURG.

Microscopical Examination of Water from Scott Reservoir, Fitchburg.

[Number of organisms per cubic centimeter.]

	1894.			
	January.	April.	July.	October.
Day of examination,	18	18	17	17
Number of sample,	11637	12050	12545	13145
PLANTS.				
Diatomaceæ,	**2**	**215**	**186**	**1,956**
Asterionella,	1	31	6	236
Melosira,	0	127	28	1,160
Synedra,	1	48	52	0
Tabellaria,	0	9	100	560
Algæ,	**0**	**2**	**4**	**69**
Arthrodesmus,	0	0	0	3
Chlorococcus,	0	0	0	2
Dictyosphærium,	0	0	0	2
Hyalotheca,	0	0	0	4
Pediastrum,	0	0	0	6
Protococcus,	0	0	0	12
Raphidium,	0	0	4	4
Scenedesmus,	0	2	0	36
ANIMALS.				
Rhizopoda, Difflugia,	**0**	**0**	**0**	**3**
Infusoria,	**34**	**68**	**69**	**96**
Ciliated infusorian,	0	0	1	0
Dinobryon,	0	1	0	0
Dinobryon cases,	0	60	0	52
Euglena,	0	1	0	0
Glenodinium,	0	6	0	0
Peridinium,	34	0	68	44
Vermes,	**0**	**6**	**2**	**2**
Anuræa,	0	1	2	0
Polyarthra,	0	5	0	1
Rotifer,	0	0	0	1
Miscellaneous, Zoöglœa,	**17**	**68**	**0**	**0**
TOTAL,	**53**	**359**	**261**	**2,126**

FITCHBURG.

Chemical Examination of Water from Meeting-house Pond, Westminster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11745	Feb. 12	V. slight.	V. slight.	0.02	2.50	0.80	.0016	.0158	.0140	.0018	.19	.0030	.0000	.1960	0.6
12049	Apr. 16	V. slight.	Slight.	0.08	2.10	0.80	.0000	.0102	.0084	.0018	.15	.0070	.0000	.2080	0.6
12398	June 18	Slight.	Slight.	0.10	2.60	1.05	.0016	.0126	.0100	.0026	.22	.0000	.0000	.2410	0.5
12544	July 16	Slight.	Cons., dark.	0.08	2.60	1.05	.0012	.0196	.0142	.0054	.19	.0050	.0001	.2279	0.8
12771	Aug. 15	Slight.	Slight, green.	0.07	2.00	0.65	.0014	.0126	.0110	.0016	.14	.0000	.0000	.2502	0.3
13144	Oct. 16	Slight.	Slight.	0.08	2.50	1.15	.0000	.0186	.0158	.0028	.19	.0000	.0000	.2172	0.5
13518	Dec. 17	Slight.	Cons.	0.05	2.35	0.55	.0018	.0150	.0138	.0012	.16	.0030	.0000	.1732	0.8
Av.	1894...	....	....	0.07	2.38	0.86	.0011	.0149	.0125	.0024	.18	.0026	.0000	.2162	0.6
Av.	1893...	....	....	0.07	2.37	0.88	.0009	.0137	.0113	.0024	.17	.0023	.0000	.2304	0.6

Odor, generally, vegetable; on one occasion also mouldy; sometimes none. On heating, the odor was sometimes stronger. —— The samples were collected from the pond, near the gate-house. The pond was full until about May 1, and from that time went gradually down until November 6, when it was 6 feet below high water. The distance, in feet below high water, on the dates when samples were collected, was approximately as follows: June 18, 0.5; July 16, 1.0; August 15, 1.8; October 16, 5.0; December 17, 5.5.

Microscopical Examination of Water from Meeting-house Pond, Westminster.

[Number of organisms per cubic centimeter.]

	1894. Feb.	April.	June.	July.	Aug.	Oct.	Dec.
Day of examination,	13	18	22	17	18	17	20
Number of sample,	11745	12049	12398	12544	12771	13144	13518
PLANTS.							
Diatomaceæ,	**4**	**18**	**9**	**7**	**15**	**1**	**98**
Cyclotella,	0	0	4	1	4	0	1
Melosira,	0	3	0	0	0	0	4
Synedra,	0	1	0	0	1	0	15
Tabellaria,	4	14	5	6	10	1	78
Cyanophyceæ,	**0**	**0**	**0**	**6**	**3**	**7**	**0**
Anabæna,	0	0	0	6	3	0	0
Microcystis,	0	0	0	0	0	7	0
Algæ,	**0**	**5**	**5**	**0**	**24**	**8**	**10**
Chlorococcus,	0	0	0	0	4	0	0
Protococcus,	0	5	5	0	20	0	6
Raphidium,	0	0	0	0	0	8	4
Fungi, Crenothrix,	**0**	**1**	**0**	**0**	**2**	**0**	**3**
ANIMALS.							
Infusoria,	**pr.**	**236**	**3**	**5**	**1**	**0**	**7**
Dinobryon,	0	36	0	0	0	0	0
Dinobryon cases,	pr.	200	1	0	0	0	7
Epistylis,	0	0	0	5	0	0	0
Peridinium,	pr.	0	2	0	1	0	0
Miscellaneous, Zoöglœa,	**5**	**30**	**72**	**0**	**68**	**0**	**0**
TOTAL,	9	290	89	18	113	16	118

FITCHBURG.

Chemical Examination of Water from Wyman's Reservoir, Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
12770	Aug. 15	Distinct.	Cons., yellow.	0.85	2.95	1.35	.0034	.0302	.0254	.0048	.12	.0000	.0000	.6483	0.5

Odor, faintly vegetable, becoming stronger on heating. —— The sample was collected from the reservoir at the gate-house, at a depth of 1 foot beneath the surface. This reservoir is not used as a source of water supply, although it is owned by the city, and is within the territory from which it is authorized to take water.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 582; *Diatoma*, 1; *Tabellaria*, 48. Cyanophyceæ, *Clathrocystis*, 3. Algæ, *Raphidium*, 4. Infusoria, *Dinobryon cases*, 19; *Tintinnidium*, 1. Miscellaneous, *Zoōglœa*, 280. Total, 938.

Water Supply of Foxborough Water Supply District, Foxborough.

Chemical Examination of Water from the Tubular Wells of the Foxborough Water Supply District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11795	Feb. 20	None.	None.	0.0	3.10	.0002	.0008	.31	.0320	.0000	.0240	0.5	.0000
12284	May 24	None.	None.	0.0	2.40	.0002	.0004	.32	.0500	.0000	.0117	1.1	.0000
12778	Aug. 18	None.	None.	0.0	2.80	.0000	.0000	.30	.0400	.0000	.0000	0.7	.0040
13351	Nov. 21	None.	None.	0.0	3.50	.0000	.0000	.36	.0400	.0000	.0078	0.6	.0000
Av.	....	....	....	0.0	2.95	.0001	.0003	.32	.0405	.0000	.0109	0.7	.0010

Odor, none. —— The samples were collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No organisms.

FRAMINGHAM.

WATER SUPPLY OF FRAMINGHAM. — FRAMINGHAM WATER COMPANY.

Chemical Examination of Water from the Filter-gallery of the Framingham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11783	Feb. 18	None.	Cons.	0.00	6.35	.0032	.0028	.63	.0580	.0000	.0680	2.7	.0140
12058	Apr. 17	None.	V. slight.	0.01	6.70	.0024	.0022	.72	.0400	.0001	.0491	2.7	.0180
12389	June 19	V. slight.	V. slight.	0.10	6.45	.0022	.0024	.82	.0380	.0000	.0847	2.5	.0310
12786	Aug. 20	V. slight.	Slight, rusty.	0.03	6.00	.0000	.0100	.88	.0050	.0002	.1540	2.7	.0180
13179	Oct. 22	V. slight.	Slight.	0.02	7.00	.0052	.0060	.88	.0220	.0000	.0893	3.0	.0680
13531	Dec. 19	Slight.	Slight.	0.03	8.00	.0020	.0024	.80	.1460	.0000	.0323	3.1	.0140
Av.	....	....	....	0.03	6.75	.0025	.0043	.79	.0515	.0001	.0796	2.8	.0272

Averages by Years.

-	1887*	-	-	0.08	5.82	.0031	.0124	.43	.0123	-	-	-	-
-	1888	-	-	0.10	5.81	.0027	.0081	.44	.0308	.0004	-	-	-
-	1889	-	-	0.00	6.18	.0031	.0050	.56	.0366	.0002	-	-	-
-	1890	-	-	0.00	7.09	.0020	.0039	.65	.0631	.0001	-	3.0	-
-	1891	-	-	0.00	6.25	.0023	.0035	.63	.0707	.0001	-	2.8	-
-	1892†	-	-	0.13	5.43	.0051	.0081	.39	.0225	.0018	-	2.6	-
-	1893	-	-	0.04	6.07	.0026	.0033	.62	.0460	.0001	.1104	2.6	.0099
-	1894	-	-	0.03	6.75	.0025	.0043	.79	.0515	.0001	.0796	2.8	.0272

* June to November. † Two samples in October.

NOTE to analyses of 1894: Odor of No. 12786, faintly tarry; of the other samples, none.——The samples were collected from the filter-gallery.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 1,001, and consisted chiefly of Crenothrix and Zoöglœa. The highest number of the former was 4,400, in the October sample; of the latter, 460, in the December sample.

FRAMINGHAM.

Chemical Examination of Water from a Faucet in South Framingham, supplied from the Works of the Framingham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11784	Feb. 18	None.	None.	0.00	5.85	.0000	.0016	.63	.0250	.0002	.0624	2.7	.0070
12059	Apr. 17	None.	Slight.	0.00	5.85	.0012	.0034	.78	.0220	.0005	.0530	2.7	.0050
12390	June 19	V. slight.	Slight, rusty.	0.08	6.55	.0000	.0030	.81	.0150	.0003	.1009	2.6	.0210
12785	Aug. 20	V. slight.	Cons., rusty.	0.03	7.10	.0000	.0042	.78	.0280	.0006	.0462	3.0	.0400
13180	Oct. 22	Slight.	Cons., rusty.	0.01	6.90	.0004	.0032	.88	.0380	.0000	.0735	3.0	.1100
13532	Dec. 19	Slight.	Slight.	0.05	6.60	.0004	.0038	.82	.0300	.0000	.0385	3.1	.0100
Av.	....	....	....	0.03	6.48	.0003	.0032	.78	.0263	.0003	.0624	2.9	.0322

Odor of the last sample, distinctly unpleasant; of the other samples, none. On heating, the odor of No. 12390 was very faintly tarry, and of No. 12785 faintly earthy. The odor of the last sample was less strong on heating.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 128, and consisted entirely of Crenothrix and Zoöglœa. The greatest number of the former present in any month was 500 in October.

Water Supply of the State Camp Ground, Framingham.

Chemical Examination of Water from Learned's Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition	Free.	Total.	Dis-solved.	Sus-pended		Nitrates.	Nitrites.		
	1894.														
12289	May 31	V. slight.	V. slight.	0.20	1.30	0.35	.0000	.0106	.0090	.0016	.22	.0000	.0000	.1001	0.1

Odor, none; on heating, faintly vegetable. —— The sample was collected from a faucet at the camp ground.

Microscopical Examination.

No organisms.

FRAMINGHAM.

Chemical Examination of Water from the Underdrain beneath the Sewers at Framingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
–	Jan. 15	Slight.	Slight, red.	.00	19.40	.0920	.0040	3.75	.5650	.0022	.1200	6.9	–
–	Mar. 14	V. slight.	Slight, red.	.00	17.70	.0760	.0040	3.15	.5250	.0033	.0500	6.4	–
–	Apr. 14	Decided.	Cons.	.00	20.80	.0760	.0000	3.25	.5000	.0017	.1000	6.6	–
–	May 14	Decided.	Cons.	.00	23.80	.0760	.0020	3.95	.6500	.0028	.0800	7.1	–
–	June 22	Decided.	Cons.	.00	28.10	.0760	.0020	4.15	.5250	.0018	.0700	7.3	–
–	July 18	Decided.	Cons.	.00	26.60	.0560	.0050	4.75	.5250	.0017	.0900	6.4	–
–	Sept. 15	Slight.	Cons.	.00	26.50	.0400	.0040	5.50	.7000	.0040	.1200	7.4	–
–	Oct. 15	Distinct.	Cons.	.00	21.10	.0360	.0060	2.95	.4500	.0030	.0900	6.6	–
–	Nov. 14	Distinct.	Cons.	.00	18.80	.0440	.0030	2.40	.4500	.0028	.0500	8.1	–
–	Dec. 14	Decided.	Cons.	.00	19.60	.0480	.0030	2.20	.4250	.0050	.0800	7.7	–
Av..	....	....	....	.00	22.24	.0620	.0033	3.61	.5315	.0028	.0850	7.1	–

Averages by Years.

Number.	Year.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
–	1889*	–	–	0 00	19.70	.0800	.0080	3.73	.4750	.0045	–	6.6	–
–	1890	–	–	0.01	19.71	.0824	.0073	3.51	.5336	.0026	–	8.4	–
–	1891	–	–	0.01	20.44	.1029	.0045	3.51	.5333	.0019	–	8.0	–
–	1892	–	–	0.01	19.32	.0805	.0042	3.99	.6667	.0018	–	8.0	–
–	1893	–	–	0.02	20.75	.0829	.0039	3.84	.6282	.0014	.0645	7.4	–
–	1894	–	–	0.00	22.24	.0620	.0033	3.61	.5315	.0028	.0850	7.1	–

* October.

NOTE to analyses of 1894: Odor, generally faintly vegetable and mouldy. —— The samples were collected from the underdrain, at its outlet.

The analysis of 1889 was made before sewage was admitted to the sewers. Several of the analyses made in 1890 and all of those of subsequent years were made by the city of Boston.

Water Supply of Franklin. — Franklin Water Company.

Chemical Examination of Water from the Wells of the Franklin Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11790	Feb. 20	None.	None.	0.00	11.50	.0002	.0020	1.32	.3750	.0000	.0352	4.6	.0040
12386	June 19	None.	None.	0.08	9.25	.0004	.0016	.91	.1800	.0000	.0731	3.4	.0080

Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No. 11790. No organisms.

No. 12386. Diatomaceæ, *Asterionella*, 7; *Diatoma*, 1; *Tabellaria*, 6. Fungi, *Crenothrix*, 1. Total, 15.

Water Supply of Gardner. — Gardner Water Company.

Chemical Examination of Water from Crystal Lake, Gardner.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11615	Jan. 9	V. slight.	V. slight.	0.05	2.85	0.95	.0014	.0122	.0102	.0020	.27	.0020	.0000	.1599	1.1
12013	Apr. 10	V. slight.	Slight.	0.02	2.55	0.80	.0004	.0112	.0085	.0024	.29	.0050	.0000	.1640	0.8
12536	July 16	None.	V. slight.	0.05	2.95	1.25	.0010	.0100	.0090	.0010	.32	.0020	.0000	.1386	1.3
13118	Oct. 10	V. slight.	V. slight.	0.03	2.65	0.90	.0006	.0112	.0098	.0014	.34	.0000	.0000	.1231	0.6
Av.	....	....	....	0.04	2.75	0.98	.0009	.0111	.0094	.0017	.31	.0023	.0000	.1464	1.0

Averages by Years.

–	1887*	–	–	0.02	2.63	0.62	.0006	.0111	–	–	.21	.0019	–	–	–
–	1888†	–	–	0.01	2.60	0.62	.0023	.0112	–	–	.22	.0094	.0001	–	–
–	1891‡	–	–	0.02	2.95	0.85	.0007	.0119	.0098	.0021	.16	.0073	.0001	–	0.7
–	1892§	–	–	0.02	2.45	0.65	.0008	.0104	.0086	.0018	.27	.0180	.0000	–	1.1
–	1893	–	–	0.05	2.65	0.82	.0012	.0126	.0105	.0021	.27	.0021	.0000	.1879	0.8
–	1894	–	–	0.04	2.75	0.98	.0009	.0111	.0094	.0017	.31	.0023	.0000	.1464	1.0

* June to December. † January to May. ‡ June, three samples. § March.

Note to analyses of 1894: Odor of the first sample, faintly vegetable; of the third, faintly disagreeable; of the others, none. On heating, the odor of the first sample became stronger and unpleasant, a faintly vegetable odor was developed in the second sample, and the odor of the third sample became stronger. —— The samples were collected from a faucet on Pearl Street.

GARDNER.

Microscopical Examination of Water from Crystal Lake, Gardner.

[Number of organisms per cubic centimeter.]

	1894.			
	January.	April.	July.	October.
Day of examination,	10	11	17	12
Number of sample,	11615	12013	12536	13118
PLANTS.				
Diatomaceæ,	34	23	pr.	2
Asterionella,	0	3	0	pr.
Cyclotella,	34	5	0	1
Synedra,	0	4	pr.	1
Tabellaria,	0	11	0	0
Cyanophyceæ, Microcystis,	0	0	32	4
Algæ,	0	6	13	2
Chlorococcus,	0	6	0	2
Protococcus,	0	0	13	0
ANIMALS.				
Infusoria,	69	99	pr.	2
Dinobryon,	13	24	0	0
Dinobryon cases,	42	70	0	2
Peridinium,	14	5	pr.	0
Vermes, Anurea,	2	0	0	0
TOTAL,	105	128	45	10

WATER SUPPLY OF GLOUCESTER.

The reply of the State Board of Health to an application of the city of Gloucester relative to taking a new water supply for the city from the Chebacco Lakes, so-called, in the towns of Essex, Hamilton and Wenham, may be found on pages 14 and 15 of this volume. Another application was made by the city on June 30, 1894, for further investigations and advice with regard to present and prospective sources of water supply; and during these investigations many samples of water from present and prospective sources in Gloucester and from the Chebacco Lakes were analyzed. The analyses of the samples collected from sources in Gloucester are given on the following pages, and those from the Chebacco Lakes are given under Essex, on pages 138–140. During the summer the amount of iron in the water from the Gloucester sources was unusually high for surface waters.

WATER SUPPLY OF GLOUCESTER. — GLOUCESTER WATER COMPANY.

Chemical Examination of Water from Dike's Brook Storage Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11944	Mar. 26	Slight.	Slight.	0.60	3.65	1.50	.0068	.0194	.0172	.0022	.96	.0030	.0000	.4456	0.1
12637	July 30	Distinct.	Slight.	0.25	3.75	1.00	.0010	.0168	.0142	.0026	.97	.0000	.0000	.3542	0.5
12841	Aug. 27	Distinct.	Slight.	0.30	4.25	1.50	.0000	.0156	.0120	.0036	.92	.0000	.0000	.3234	0.3
13021	Sept. 24	Slight.	Cons.	0.20	3.80	1.20	.0008	.0160	.0126	.0034	.96	.0000	.0000	.3326	0.5
13231	Oct. 29	Slight.	V. slight.	0.60	4.05	1.25	.0070	.0186	.0158	.0028	.98	.0030	.0000	.4312	0.2
13391	Nov. 26	Slight.	Slight.	0.68	3.75	1.05	.0024	.0174	.0150	.0024	1.00	.0050	.0000	.5084	0.2
13573	Dec. 31	V. slight.	V. slight.	0.85	4.25	1.55	.0058	.0204	.0204	.0000	1.10	.0050	.0000	.5890	0.3
Av.	....	....	....	0.50	3.93	1.29	.0034	.0177	.0153	.0024	0.98	.0023	.0000	.4263	0.3

Odor, generally distinctly vegetable, sometimes mouldy, unpleasant or grassy.——The samples were collected from the reservoir.

Microscopical Examination of Water from Dike's Brook Storage Reservoir.

[Number of organisms per cubic centimeter.]

	1894. Mar.	1894. Aug.	1894. Aug.	1894. Sept.	1894. Nov.	1894. Nov.	1895. Jan.
Day of examination,	29	1	30	26	1	28	2
Number of sample,	11944	12637	12841	13021	13231	13391	13573
PLANTS.							
Diatomaceæ,	**2**	**36**	**3,040**	**0**	**0**	**0**	**0**
Synedra,	2	0	3,040	0	0	0	0
Tabellaria,	0	36	0	0	0	0	0
Cyanophyceæ, Merismopedia,	**0**	**4**	**0**	**0**	**10**	**0**	**0**
Algæ,	**96**	**4**	**0**	**0**	**1,058**	**1,440**	**42**
Chlorococcus,	0	0	0	0	600	0	0
Glœocapsa,	96	0	0	0	3	0	pr.
Protococcus,	0	0	0	0	340	1,440	42
Raphidium,	0	4	0	0	115	0	0
Fungi, Crenothrix,	**3**	**0**	**0**	**11**	**0**	**13**	**pr.**

GLOUCESTER.

Microscopical Examination of Water from Dike's Brook Storage Reservoir — Concluded.

[Number of organisms per cubic centimeter.]

	1894.						1895.
	Mar.	Aug.	Aug.	Sept.	Nov.	Nov.	Jan.
ANIMALS.							
Infusoria,	62	38	8	0	0	0	2
Chlamydomonas,	62	0	0	0	0	0	0
Cryptomonas,	0	0	0	0	0	0	1
Dinobryon cases,	0	0	4	0	0	0	0
Monas,	0	2	0	0	0	0	0
Peridinium,	0	36	3	0	0	0	1
Trachelomonas,	0	0	1	0	0	0	0
Vermes,	0	2	1	1	0	0	0
Monocerca,	0	0	0	1	0	0	0
Polyarthra,	0	1	1	0	0	0	0
Rotifer,	0	1	0	0	0	0	0
Miscellaneous, Zoöglœa,	0	28	64	44	0	0	0
TOTAL,	163	112	3,113	56	1,068	1,453	44

Chemical Examination of Water from Wallace Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11945	Mar. 26	Distinct.	Slight.	0.60	3.70	0.90	.0016	.0198	.0170	.0028	1.04	.0030	.0000	.3580	0.1
12636	July 30	Decided, green.	Cons.	0.90	4.40	1.15	.0000	.0252	.0208	.0044	1.17	.0000	.0000	.4697	0.6
12696	Aug. 8	Distinct, green.	Slight, green.	0.90	4.85	1.75	.0018	.0308	.0206	.0102	1.06	.0000	.0000	.4959	0.9
12840	Aug. 27	Distinct.	Slight, rusty.	0.95	5.30	1.70	.0004	.0260	.0220	.0040	1.16	.0000	.0000	.4697	0.5
13022	Sept 24	Slight.	Slight.	0.70	4.75	1.90	.0006	.0310	.0220	.0090	1.18	.0000	.0000	.5190	0.5
13230	Oct. 29	Distinct.	Slight.	0.70	4.90	2.00	.0004	.0384	.0252	.0132	1.19	.0000	.0000	.5236	0.6
13392	Nov. 26	Slight.	Cons.	0.70	5.25	1.85	.0056	.0420	.0252	.0168	1.20	.0030	.0000	.6806	0.5
13578	Dec. 31	Distinct.	Slight.	0.70	5.20	1.95	.0034	.0416	.0270	.0146	1.28	.0050	.0000	.5544	0.8
Av.	....	....	....	0.77	4.79	1.65	.0017	.0319	.0225	.0094	1.16	.0014	.0000	.5089	0.6

Odor, generally vegetable and unpleasant or disagreeable, becoming somewhat stronger on heating, and in the last sample also oily. —— The samples were collected from Wallace Pond, which is an artificial reservoir.

GLOUCESTER.

Microscopical Examination of Water from Wallace Pond.

[Number of organisms per cubic centimeter.]

	1894.							1895.
	Mar.	Aug.	Aug.	Aug.	Sept.	Nov.	Nov.	Jan.
Day of examination,	29	1	10	30	26	1	28	3
Number of sample,	11945	12636	12696	12840	13022	13230	13392	13578
PLANTS.								
Diatomaceæ,	**33**	**18**	**19**	**43**	**132**	**309**	**0**	**360**
Asterionella,	33	18	19	36	128	308	0	360
Tabellaria,	0	0	0	7	4	1	0	0
Algæ,	**18**	**0**	**0**	**2**	**76**	**0**	**0**	**0**
Hyalotheca,	0	0	0	0	4	0	0	0
Protococcus,	2	0	0	0	72	0	0	0
Zoöspores,	16	0	0	2	0	0	0	0
Fungi, Crenothrix,	**1**	**0**	**0**	**1**	**4**	**0**	**0**	**0**
ANIMALS.								
Infusoria,	**58**	**194**	**137**	**3**	**76**	**268**	**1**	**290**
Chlamydomonas,	16	0	0	0	0	0	0	0
Ciliated infusorian,	0	0	0	0	0	0	0	2
Cryptomonas,	0	0	0	0	0	100	0	4
Dinobryon cases,	42	0	0	0	0	0	0	0
Monas,	0	2	1	0	0	0	0	0
Peridinium,	0	192	136	3	76	168	1	284
Vermes,	**0**	**0**	**0**	**1**	**0**	**12**	**0**	**0**
Anurea,	0	0	0	0	0	11	0	0
Monocerca,	0	0	0	1	0	0	0	0
Rotifer,	0	0	0	0	0	1	0	0
Miscellaneous, Zoöglœa,	**0**	**152**	**0**	**228**	**96**	**0**	**0**	**0**
TOTAL,	110	364	156	278	384	589	1	650

Chemical Examination of Water from a Faucet at City Hall, Gloucester, supplied from the Works of the Gloucester Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12638	July 31	Distinct.	Cons., rusty.	0.55	4.50	1.25	.0014	.0168	.0140	.0028	1.03	.0030	.0001	.3249	0.9
12693	Aug. 8	Slight.	Slight.	0.65	4.55	1.35	.0004	.0196	.0152	.0044	0.90	.0000	.0000	.4058	0.7
13023	Sept. 24	Distinct.	Cons.	0.40	3.90	1.25	.0120	.0144	.0090	.0054	0.98	.0000	.0000	.2064	0.6
13389	Nov. 26	Slight.	Cons.	0.60	4.25	1.45	.0000	.0184	.0164	.0020	1.00	.0100	.0000	.4756	0.5
13574	Dec. 31	V. slight.	V. slight.	0.65	3.85	1.45	.0026	.0174	.0164	.0010	0.99	.0070	.0000	.4389	0.5
Av.	....	....	....	0.57	4.21	1.35	.0033	.0173	.0142	.0031	0.98	.0040	.0000	.3703	0.6

Odor, vegetable and occasionally mouldy.

GLOUCESTER.

Microscopical Examination of Water from a Faucet at City Hall, Gloucester, supplied from the Works of the Gloucester Water Company.

[Number of organisms per cubic centimeter.]

	1894.				1895.
	August.	August.	September.	November.	January.
Day of examination,	1	10	26	28	2
Number of sample,	12638	12693	13023	13389	13574
PLANTS.					
Diatomaceæ,	**20**	**3**	**0**	**11**	**2**
Asterionella,	4	0	0	0	0
Fragilaria,	15	0	0	2	0
Melosira,	0	0	0	9	0
Synedra,	1	3	0	0	2
Algæ, Protococcus,	**0**	**0**	**0**	**176**	**0**
Fungi, Crenothrix,	**2,080**	**28**	**7**	**60**	**0**
ANIMALS.					
Rhizopoda, Arcella,	**0**	**0**	**0**	**1**	**0**
Infusoria,	**3**	**3**	**0**	**0**	**0**
Ciliated infusorian,	0	1	0	0	0
Euglena,	0	1	0	0	0
Peridinium,	3	0	0	0	0
Trachelomonas,	0	1	0	0	0
Miscellaneous, Zoöglœa,	**0**	**56**	**632**	**0**	**0**
TOTAL,	2,103	90	639	248	2

Chemical Examination of Water from Lily Pond Brook, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12697	Aug 8	Distinct.	Cons., rusty.	2.20	8.25	3.80	.0008	.0512	.0396	.0116	.90	.0030	.0000	1.7804	1.8
12836	Aug. 27	Distinct.	Cons., rusty.	2.70	8.95	3.95	.0010	.0578	.0438	.0140	1.17	.0000	.0000	1.6016	0.9
13020	Sept. 24	Slight.	Cons.	1.80	7.20	3.00	.0014	.0320	.0314	.0006	1.13	.0000	.0000	1.1319	0.8
13232	Oct. 29	V. slight.	Cons.	0.90	7.15	2.35	.0000	.0218	.0198	.0020	1.44	.0030	.0000	.8585	1.3
13396	Nov. 26	V. slight.	Slight.	1.70	7.10	2.65	.0000	.0242	.0226	.0016	1.28	.0000	.0000	1.6400	0.9
13576	Dec. 31	Slight.	Slight.	1.80	6.65	2.85	.0008	.0258	.0234	.0024	1.36	.0000	.0000	1.0934	1.1
Av.	....	....	....	1.85	7.55	3.10	.0007	.0355	.0301	.0054	1.21	.0010	.0000	1.3510	1.1

Odor, generally distinctly vegetable and sometimes unpleasant. —— The samples were collected from the brook, near the pumping station of the Gloucester Water Company.

GLOUCESTER.

Microscopical Examination of Water from Lily Pond Brook, Gloucester.

[Number of organisms per cubic centimeter.]

	1894.					1895.
	Aug.	Aug.	Sept.	Nov.	Nov.	Jan.
Day of examination,	10	29	26	1	28	2
Number of sample,	12697	12836	13020	13232	13396	13576
PLANTS.						
Diatomaceæ,	1	41	0	1	1	0
Asterionella,	0	4	0	0	0	0
Epithemia,	0	4	0	0	1	0
Melosira,	0	8	0	0	0	0
Navicula,	0	4	0	1	0	0
Pinnularia,	0	9	0	0	0	0
Synedra,	1	8	0	0	0	0
Tabellaria,	0	4	0	0	0	0
Fungi, Crenothrix,	1,080	248	480	216	2	0
ANIMALS.						
Rhizopoda, Arcella,	0	1	0	0	0	0
Infusoria,	2	2	1	0	14	47
Ciliated infusorian,	0	1	0	0	0	0
Dinobryon,	0	0	0	0	3	4
Dinobryon cases,	0	0	0	0	10	40
Euglena,	0	0	0	0	0	1
Monas,	0	0	1	0	0	0
Peridinium,	2	1	0	0	1	2
Vermes, Rotifer,	0	1	0	0	0	0
Miscellaneous, Zoöglœa,	856	0	0	0	10	172
TOTAL,	1,939	293	481	217	27	219

GLOUCESTER.

Chemical Examination of Water from a Brook crossing Magnolia Avenue, South-west of Lily Pond, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12698	Aug. 8	None.	V. slight.	5.00	11.05	6.90	.0000	.0436	.0392	.0044	.82	.0070	.0000	4.0656	1.8
13394	Nov. 26	V. slight.	V. slight.	2.80	9.30	4.95	.0006	.0306	.0274	.0032	1.18	.0000	.0000	3.2800	1.4
13581	Dec. 31	None.	V. slight	1.70	6.65	3.30	.0004	.0252	.0242	.0010	1.02	.0000	.0000	2.1175	0.9
Av.	....	....	....	3.17	9.00	5.05	.0003	.0331	.0303	.0028	1.01	.0023	.0000	3.1544	1.4

Odor of the first sample, none; of the others, distinctly vegetable. —— The samples were collected from the first brook crossing Magnolia Avenue, south-west of Lily Pond, at a point just above the avenue. The brook flows in a southerly direction, and is a tributary of a brook discharging into the sea at Kettle Cove. This is not a source of water supply for the city of Gloucester.

Microscopical Examination.

No. 12698. Miscellaneous, *Zoöglœa*, 4.
No. 13394. No organisms.
No. 13581. Diatomaceæ, *Asterionella*, 2; *Synedra*, 2. Total, 4.

Chemical Examination of Water from a Brook flowing from Magnolia and Cedar Swamps, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12699	Aug. 8	None.	Slight.	6.25	4.85	2.25	.0008	.0424	.0368	.0056	0.80	.0000	.0000	4.8642	1.4
13395	Nov. 26	V. slight.	Slight.	1.80	7.15	3.20	.0002	.0180	.0160	.0020	1.35	.0000	.0000	1.9844	0.9
13582	Dec. 31	V. slight	Cons., reddish.	1.50	5.50	2.65	.0004	.0174	.0160	.0014	1.15	.0000	.0000	1.3475	0.8
Av.	....	....	....	3.18	5.83	2.70	.0005	.0259	.0229	.0030	1.10	.0000	.0000	2.7320	1.0

Odor of the first sample, none; of the second, distinctly vegetable and unpleasant; and of the third, very faintly vegetable. —— The samples were collected from the brook near where it crosses Western Avenue. This brook is a tributary of the brook from which the samples in the preceding table were collected. This is not a source of water supply for the city of Gloucester.

Microscopical Examination.

No. 12699. Diatomaceæ, *Synedra*, 3. Rhizopoda, *Arcella*, 1. Miscellaneous, *Zoöglœa*, 14. Total, 18.
No. 13395. Diatomaceæ, *Fragilaria*, 2. Fungi, *Crenothrix*, 10. Total, 12.
No. 13582. Diatomaceæ, *Asterionella*, 4; *Diatoma*, 9. Fungi, *Crenothrix*, 4. Total, 17.

GLOUCESTER.

Chemical Examination of Water from Norman's Woe Brook, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended		Nitrates.	Nitrites.		
	1894.														
13397	Nov. 26	V. slight.	Slight.	5.00	12.40	7.85	.0006	.0496	.0474	.0022	1.24	.0000	.0000	5.0430	1.7
13580	Dec. 31	V. slight.	V. slight.	3.60	8.15	5.05	.0008	.0314	.0288	.0026	1.00	.0000	.0000	3.1570	0.9

Odor, vegetable. —— The samples were collected from Norman's Woe Brook in Magnolia Swamp, about one-fourth mile below Western Avenue. This is not a source of water supply for the city of Gloucester.

Microscopical Examination.

No. 13397. Diatomaceæ, *Diatoma*, 1. Infusoria, *Peridinium*, 1. Total, 2.
No. 13580. No organisms.

Chemical Examination of Water from Fernwood Lake, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12694	Aug. 8	Slight.	Slight.	2.10	6.05	2.75	.0000	.0304	.0270	.0034	1.05	.0070	.0000	1.1588	0.6
12837	Aug. 27	Decided.	Slight.	2.40	6.15	3.40	.0000	.0342	.0266	.0076	1.16	.0000	.0000	1.1858	0.9
13019	Sept. 24	Distinct.	Slight.	2.60	6.00	2.40	.0014	.0354	.0308	.0046	1.18	.0000	.0000	.7546	0.5
13228	Oct. 29	Slight.	Slight.	1.90	5.80	1.95	.0074	.0308	.0278	.0030	1.19	.0030	.0000	1.1742	0.8
13388	Nov. 26	Slight.	Slight.	2.50	7.25	3.40	.0030	.0394	.0262	.0132	1.30	.0030	.0000	2.1730	0.8
13579	Dec. 31	Slight.	Slight.	2.50	7.15	3.40	.0054	.0364	.0336	.0028	1.30	.0050	.0000	1.8634	0.8
Av.	....	....	....	2.33	6.40	2.88	.0029	.0344	.0287	.0057	1.20	.0030	.0000	1.3850	0.7

Odor of the first sample, distinctly vegetable and mouldy; of the second, faintly vegetable, becoming disagreeable after standing one day; of the third, very disagreeable; of the fourth, none; of the fifth, faintly vegetable; and of the last, distinctly vegetable. The odor of all samples except the last was stronger on heating. —— The samples were collected from Fernwood Lake, from the end of the wharf at Homan's ice-house. This is not a source of water supply for the city of Gloucester.

GLOUCESTER.

Microscopical Examination of Water from Fernwood Lake, Gloucester.

[Number of organisms per cubic centimeter.]

	1894.					1895.
	August.	August.	September.	November	November.	January.
Day of examination,	10	29	26	1	28	3
Number of sample,	12694	12837	13019	13228	13388	13579
PLANTS.						
Diatomaceæ,	198	1,620	357	21	19	13
Asterionella,	2	18	332	20	18	13
Diatoma,	148	2	0	0	1	0
Synedra,	48	1,600	25	1	0	0
Cyanophyceæ,	0	0	9	0	0	0
Aphanocapsa,	0	0	3	0	0	0
Cœlosphærium,	0	0	6	0	0	0
Algæ,	1	2	93	3	4	2
Dictyosphærium,	0	0	0	2	4	0
Protococcus,	0	0	86	0	0	0
Scenedesmus,	0	0	7	1	0	0
Zoöspores,	1	2	0	0	0	2
Fungi, Crenothrix,	1	3	1	0	0	0
ANIMALS.						
Rhizopoda, Euglypha,	1	0	0	0	0	0
Infusoria,	150	224	4	0	3	132
Ciliated infusorian,	0	0	0	0	1	0
Dinobryon,	0	0	0	0	0	3
Dinobryon cases,	2	0	0	0	0	49
Euglena,	20	0	0	0	1	10
Monas,	1	0	0	0	0	0
Peridinium,	120	224	4	0	0	80
Trichodina,	0	0	0	0	1	0
Trachelomonas,	7	0	0	0	0	0
Vermes,	4	0	0	0	0	1
Polyarthra,	0	0	0	0	0	1
Rotifer,	4	0	0	0	0	0
Miscellaneous, Zoöglœa,	380	52	15	0	0	0
TOTAL,	735	1,901	479	24	26	148

GLOUCESTER.

Chemical Examination of Water from Haskell's Brook, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
12695	Aug. 8	Decided, green.	Slight, green.	2.50	8.40	4.90	.0008	.0924	.0556	.0368	.84	.0000	.0000	2.1868	0.9
12839	Aug. 27	Thick.	Cons., rusty.	3.25	8.50	5.10	.0000	.1056	.0770	.0286	1.09	.0030	.0000	2.1714	0.5
13018	Sept. 24	Decided.	Heavy.	3.00	9.85	5.50	.0670	.1560	.0720	.0840	1.04	.0020	.0000	2.2946	0.6
13229	Oct. 29	Distinct.	Cons.	1.70	7.50	3.80	.0092	.0562	.0504	.0058	1.09	.0030	.0000	1.7440	1.3
13393	Nov. 26	V. slight.	Slight.	0.75	5.70	2.30	.0004	.0166	.0150	.0016	1.18	.0000	.0000	.8651	0.8
13575	Dec. 31	Slight.	Slight.	0.90	4.90	2.00	.0012	.0168	.0138	.0030	1.38	.0000	.0000	.7045	0.6
Av.	....	....	....	2.02	7.48	3.93	.0131	.0739	.0473	.0266	1.10	.0013	.0000	1.6611	0.8

Odor of the first sample, decidedly unpleasant; of the second, decidedly disagreeable; of the third, distinct; of the remaining samples, vegetable. —— The samples were collected from Haskell's Brook, West Gloucester, just above the dam of Haskell's Reservoir. This reservoir had not been flowed for a long time before the samples were collected. This is not a source of water supply for the city of Gloucester.

Microscopical Examination of Water from Haskell's Brook, Gloucester.

[Number of organisms per cubic centimeter.]

	1894.					1895.
	Aug.	Aug.	Sept.	Nov.	Nov.	Jan.
Day of examination,	10	29	26	1	28	2
Number of sample,	12695	12839	13018	13229	13393	13575
PLANTS.						
Diatomaceæ,	**699**	**85**	**54**	**36**	**0**	**3**
Asterionella,	19	5	8	0	0	3
Navicula,	0	0	8	0	0	0
Synedra,	680	80	38	36	0	0
Cyanophyceæ,	**3**	**0**	**14**	**0**	**0**	**0**
Anabæna,	3	0	6	0	0	0
Cœlosphærium,	0	0	8	0	0	0
Algæ,	**1**	**3**	**20**	**6**	**0**	**0**
Botryococcus,	1	0	4	0	0	0
Protococcus,	0	0	6	0	0	0
Raphidium,	0	2	6	5	0	0
Scenedesmus,	0	1	2	0	0	0
Staurastrum,	0	0	2	1	0	0
Fungi, Crenothrix,	**1**	**0**	**4**	**0**	**1**	**0**

GLOUCESTER.

Microscopical Examination of Water from Haskell's Brook, Gloucester — Concluded.

[Number of organisms per cubic centimeter.]

	1894.					1895.
	Aug.	Aug.	Sept.	Nov.	Nov.	Jan.
ANIMALS.						
Infusoria,	215	496	902	474	13	108
Dinobryon,	0	0	0	4	0	0
Dinobryon cases,	120	376	0	308	0	0
Euglena,	2	0	4	0	0	0
Monas,	44	0	2	2	0	0
Ophiocytium,	4	0	0	0	0	0
Peridinium,	36	4	896	160	13	108
Synura,	2	72	0	0	0	0
Trachelomonas,	7	44	0	0	0	0
Vermes,	43	5	8	5	0	0
Anurea,	13	0	8	2	0	0
Polyarthra,	19	2	0	2	0	0
Rotatorian ova,	11	0	0	0	0	0
Rotifer,	0	3	0	1	0	0
Crustacea, Cyclops,	.01	0	.05	0	0	0
Miscellaneous,	.03	0	66	80	0	0
Acarina,	.03	0	.03	.01	0	0
Zoöglœa,	0	0	66	80	0	0
TOTAL,	962	589	1,068	601	14	111

WATER SUPPLY OF GRAFTON. — GRAFTON WATER COMPANY.

Chemical Examination of Water from the Filter-gallery of the Grafton Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12376	June 13	None.	None.	0.00	11.60	.0000	.0012	1.55	.2800	.0000	.0601	4.3	.0020
13125	Oct. 12	Distinct, milky.	V. slight.	0.04	9.10	.0000	.0032	1.10	.2500	.0000	.0038	3.5	.0230

Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No. 12376. Diatomaceæ, *Tabellaria*, 1.
No. 13125. No organisms.

GRAFTON.

Chemical Examination of Water from the East Branch of Bummet Brook, Grafton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
10841	Aug. 16	V. slight.	Slight.	0.2	4.35	1.95	.0010	.0134	.0120	.0014	.25	.0000	.0000	.2816	1.3

Odor, faintly vegetable. —— The sample was collected from the east branch of Bummet Brook, above the railroad, while making an investigation for a metropolitan water supply.

Microscopical Examination.

Diatomaceæ, *Melosira*, 7; *Synedra*, 4. Fungi, *Crenothrix*, 96. Miscellaneous, *Zoöglœa*, 24. Total, 131.

Water Supply of Greenfield.

The advice of the State Board of Health to the water commissioners of Fire District No. 1 of Greenfield, relative to increasing the water supply of the district, may be found on pages 16 and 17 of this volume. Analyses of samples of water collected from the present reservoir and from other sources in connection with the investigations for an additional water supply are given below.

Chemical Examination of Water from Glen Brook Reservoir and from the East Branch of Glen Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11901	Mar 15	None.	Slight.	0.01	3.90	0.40	.0000	.0058	.0040	.0018	.13	.0150	.0000	.0920	2.3
11900	Mar. 15	None.	Slight, dark.	0.02	2.90	0.65	.0000	.0088	.0070	.0018	.13	.0180	.0000	.1016	1.4

Odor of both samples, none. —— The first sample was collected from Glen Brook Reservoir and the second from the east branch of Glen Brook at the Herron Farm in Leyden, at the location of a proposed new reservoir of the Greenfield Fire District, about 1 mile above the present reservoir.

Microscopical Examination.

No. 11901. Diatomaceæ, *Melosira*, 2; *Meridion*, 1; *Navicula*, 2. Total, 5.
No. 11900. Diatomaceæ, *Diatoma*, 1; *Meridion*, 6; *Navicula*, 1. Total, 8.

GREENFIELD.

Chemical Examination of Water from Workman Brook in Colrain and from Fisk or Hinsdale Brook in Shelburne.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11938	Mar. 22	V. slight.	Slight.	0.03	4.25	1.15	.0008	.0038	.0034	.0004	.10	.0090	.0000	.1224	2.2
11939	Mar. 22	None.	V. slight.	0.01	5.40	0.70	.0008	.0034	.0032	.0002	.09	.0050	.0000	.1367	3.1

Odor of both samples, none, becoming very faintly vegetable on heating.——The first sample was collected from Workman Brook, about half a mile above its confluence with the Green River; and the second sample from Fisk or Hinsdale Brook, just above its confluence with Stewart Brook, about a quarter of a mile above the boundary line between Shelburne and Greenfield.

Microscopical Examination.

No. 11938. Algæ, *Closterium*, 1. Fungi, *Crenothrix*, 5; *Molds*, 1. Infusoria, *Dinobryon cases*, 1. Total, 8.

No. 11939. Diatomaceæ, *Synedra*, 1. Fungi, *Crenothrix*, 1. Total, 2.

GROVELAND.

Chemical Examination of Water from Johnson's Pond, Groveland.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12901	Sept. 6	V. slight.	Slight.	0.10	3.55	1.25	.0002	.0148	.0128	.0020	.35	.0000	.0000	.2618	1.9

Odor, faintly vegetable and mouldy.——The sample was collected from the pond, 150 feet from the west shore, in connection with an investigation for a new water supply for Bradford.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 150; *Synedra*, 6. Cyanophyceæ, *Microcystis*, 1. Algæ, *Protococcus*, 1. Infusoria, *Peridinium*, 26. Miscellaneous, *Zoöglœa*, 32. Total, 216.

Water Supply of Haverhill.

Chemical Examination of Water from Crystal Lake, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11797	Feb. 21	V. slight.	Slight.	0.10	3.25	0.90	.0038	.0352	.0296	.0056	.30	.0020	.0000	.3520	0.9
12417	June 20	Slight.	Slight.	0.30	2.90	1.05	.0002	.0156	.0150	.0006	.23	.0000	.0000	.3919	0.9
13204	Oct. 23	Distinct.	Cons., green.	0.10	3.00	1.15	.0010	.0152	.0134	.0018	.27	.0000	.0000	.2820	1.3
Av.	....	....	....	0.17	3.05	1.03	.0017	.0220	.0193	.0027	.27	.0007	.0000	.3420	1.0

Odor of the first sample, distinctly vegetable; of the other two, faintly vegetable, becoming stronger, and, in the second sample, also mouldy, on heating. —— The first and last samples were collected from the lake, and the second from a faucet at the office of the Haverhill Water Works.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 1; in June, 159; in October, 320.

Chemical Examination of Water from Kenoza Lake, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11798	Feb. 21	V. slight.	Slight.	0.04	3.35	0.95	.0034	.0150	.0136	.0014	.43	.0020	.0000	.2160	1.7
12419	June 20	Slight.	V. slight.	0.05	3.50	0.60	.0006	.0132	.0128	.0004	.36	.0030	.0000	.2218	1.4
13201	Oct. 23	Slight.	Cons.	0.08	3.35	0.65	.0004	.0162	.0132	.0030	.40	.0030	.0000	.2330	1.7
Av.	....	....	....	0.06	3.40	0.73	.0015	.0148	.0132	.0016	.40	.0027	.0000	.2236	1.6

Odor of the first and last samples, distinctly vegetable; of the second, none. —— The samples were collected from the lake.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 0; in June, 70; in October, 8.

HAVERHILL.

Chemical Examination of Water from Lake Saltonstall, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11799	Feb. 21	V. slight.	V. slight.	0.03	4.60	0.85	.0048	.0144	.0126	.0018	.61	.0040	.0001	.1664	1.8
12420	June 20	Distinct.	Slight.	0.15	5.20	1.05	.0018	.0156	.0142	.0014	.68	.0000	.0000	.1933	2.2
13203	Oct. 23	Slight.	Cons., green.	0.07	5.20	1.35	.0008	.0166	.0148	.0018	.71	.0030	.0000	.1580	2.2
Av.	....	....	....	0.08	5.00	1.08	.0025	.0155	.0139	.0017	.67	.0023	.0000	.1726	2.1

Odor of the first sample, distinctly vegetable and grassy; of the second, distinctly mouldy; of the last, decidedly vegetable and unpleasant. —— The samples were collected from the lake, which is also known as Plug Pond.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 0; in June, 140; in October, 835.

Chemical Examination of Water from Lake Pentucket, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12418	June 20	Slight.	V. slight.	0.15	4.00	0.90	.0014	.0180	.0164	.0016	.41	.0000	.0000	.2579	1.4
13202	Oct. 23	V. slight.	V. slight.	0.05	3.95	1.50	.0008	.0188	.0170	.0018	.44	.0000	.0000	.2330	1.8

Odor of the first sample, faintly vegetable; of the second, distinctly vegetable. The odor of both samples was less strong on heating. —— The samples were collected from the lake, which is also known as Round Pond.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 12418, 11; No. 13202, 156.

HAVERHILL.

Chemical Examination of Water from East Meadow River, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
12894	Sept. 5	V. slight.	V. slight.	0.23	5.05	1.00	.0002	.0070	.0062	.0008	.28	.0020	.0000	.1617	2.2
12895	Sept. 5	V. slight.	Slight.	0.23	5.25	1.30	.0016	.0064	.0058	.0006	.30	.0020	.0000	.1771	2.2
13498	Dec. 17	V. slight.	V. slight.	0.90	6.30	2.40	.0010	.0216	.0198	.0018	.36	.0050	.0000	.8624	2.9
Av.	....	....	....	0.45	5.53	1.57	.0009	.0117	.0106	.0011	.31	.0030	.0000	.4004	2.4

Odor of the first sample, distinctly vegetable, mouldy and grassy; of the second, faintly vegetable and mouldy; of the last, distinctly vegetable. —— The first sample was collected from the river, about 1½ miles from its mouth, at Thompson's bridge; the last two samples were collected just above the point where the river crosses Millvale Road, about half a mile from its mouth. The samples were collected during an investigation for an additional water supply for Haverhill.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 12894, 117; No. 12895, 104; No. 13498, 9.

Chemical Examination of Water from Little River and Creek Brook, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
12893	Sept. 5	V. slight.	Slight.	0.55	5.60	1.55	.0008	.0112	.0100	.0012	.32	.0030	.0001	.2849	1.8
13497	Dec. 17	Slight.	Cons.	0.60	5.55	1.90	.0000	.0202	.0180	.0022	.39	.0250	.0000	.6083	1.9

Odor of the first sample, distinctly vegetable and mouldy; of the second, distinctly vegetable. —— The first sample was collected from Little River, at Rosemont bridge; the last from Creek Brook, West Parish, at Bradley's mills, near its mouth. The samples were collected during an investigation for an additional water supply for Haverhill.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 12893, 136; No. 13497, 126.

HINGHAM.

Water Supply of Hingham and Hull. — Hingham Water Company.

The advice of the State Board of Health to the Hingham Water Company, relative to taking an additional water supply for Hingham and Hull from Accord Brook and Cushing Pond in Hingham, may be found on pages 17–20 of this volume. Analyses of samples of water from the present sources of supply of the Hingham Water Company and of samples collected during the investigation for an additional supply are given below.

Chemical Examination of Water from Accord Pond, Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11926	Mar. 20	Slight.	Slight.	0.25	2.70	0.95	.0004	.0122	.0102	.0020	.61	.0030	.0000	.3476	0.3
12321	June 5	Slight.	Slight.	0.25	3.15	1.15	.0000	.0120	.0108	.0012	.58	.0030	.0000	.3965	0.5
12422	June 20	Slight.	Slight.	0.20	2.95	1.05	.0000	.0098	.0082	.0016	.63	.0030	.0000	.3627	0.2
13010	Sept. 19	V. slight.	V. slight.	0.10	3.50	1.25	.0002	.0102	.0086	.0016	.71	.0000	.0000	.2310	0.3
13503	Dec. 17	V. slight.	V. slight.	0.18	2.90	1.15	.0002	.0126	.0106	.0020	.57	.0030	.0000	.3080	0.3
Av.	....	....	....	0.20	3.04	1.11	.0002	.0114	.0097	.0017	.62	.0024	.0000	.3292	0.3

Odor of the first sample, faintly vegetable; of the second, decidedly vegetable, mouldy and disagreeable, becoming mouldy and grassy on heating; of the third, distinctly mouldy and grassy, becoming vegetable on heating; of the fourth, strongly grassy; and of the last, none. —— The samples were collected from the lake.

In the early part of June complaints were made from all parts of the town of a disagreeable taste and odor in the water supply, which was being furnished at that time almost wholly from Accord Pond. A special microscopical investigation showed the presence of large numbers of the organism Anabæna, which is thought to have caused the trouble.

HINGHAM.

Microscopical Examination of Water from Accord Pond, Hingham.

[Number of organisms per cubic centimeter.]

	1894.				
	March.	June.	June.	September.	December.
Day of examination,	21	6	23	21	20
Number of sample,	11926	12321	12422	13010	13503
PLANTS.					
Diatomaceæ,	**110**	**22**	**31**	**22**	**29**
Asterionella,	5	5	0	0	7
Cyclotella,	pr.	2	24	0	4
Melosira,	5	15	5	22	2
Synedra,	76	0	0	0	16
Tabellaria,	24	0	2	0	0
Cyanophyceæ,	**0**	**17**	**9**	**19**	**0**
Anabæna,	0	8	0	0	0
Merismopedia,	0	4	8	11	0
Microcystis,	0	5	1	8	0
Algæ,	**0**	**45**	**22**	**8**	**0**
Botrycoccus,	0	20	0	0	0
Protococcus,	0	15	0	1	0
Raphidium,	0	10	22	7	0
ANIMALS.					
Rhizopoda,	**0**	**0**	**0**	**3**	**0**
Actinophrys,	0	0	0	2	0
Arcella,	0	0	0	1	0
Infusoria,	**210**	**0**	**7**	**1**	**62**
Cryptomonas,	0	0	0	0	2
Dinobryon,	27	0	0	0	3
Dinobryon cases,	180	0	2	0	56
Monas,	0	0	0	0	1
Peridinium,	3	0	5	1	0
Miscellaneous, Zoöglœa,	**3**	**0**	**0**	**12**	**0**
TOTAL,	323	84	69	65	91

HINGHAM.

Chemical Examination of Water from Fulling Mill Pond, Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11927	Mar. 20	V. slight.	Cons.	0.20	4.55	1.25	.0006	.0054	.0038	.0016	.61	.0220	.0000	.2251	1.3
12421	June 20	Slight.	Slight, rusty.	0.10	4.55	1.05	.0008	.0036	.0030	.0006	.61	.0070	.0000	.1186	1.3
12679	Aug. 7	Decided, yellow.	Cons., yellow.	0.18	5.40	0.90	.0526	.0822	.0218	.0604	.80	.0050	.0002	.2595	1.5
13011	Sept. 19	V. slight.	V. slight.	0.15	5.00	1.20	.0008	.0034	.0028	.0006	.59	.0220	.0000	.1309	0.9
13504	Dec. 17	V. slight.	Slight.	0.45	4.85	1.20	.0002	.0112	.0094	.0018	.58	.0250	.0000	.3157	1.4
Av.	....	....	....	0.22	4.87	1.12	.0110	.0212	.0082	.0130	.64	.0162	.0000	.2099	1.3

Odor of the first sample, faintly vegetable, somewhat unpleasant; of the second, none; of the third, distinct, sweetish; of the fourth, slightly vegetable and mouldy; and of the last, distinctly vegetable. —— The samples were collected from the pond.

Microscopical Examination of Water from Fulling Mill Pond, Hingham.

[Number of organisms per cubic centimeter.]

	1894. March.	June.	August.	September.	December.
Day of examination,	21	23	8	21	20
Number of sample,	11927	12421	12679	13011	13504
PLANTS.					
Diatomaceæ,	4	6	5,500	3	2
Diatoma,	pr.	5	0	0	1
Melosira,	1	0	2,900	0	0
Synedra,	3	1	2,600	3	1
Cyanophyceæ, Anabæna,	0	0	9,200	0	0
Algæ,	0	0	9,500	0	0
Chlorococcus,	0	0	8,600	0	0
Polyedrium,	0	0	50	0	0
Raphidium,	0	0	650	0	0
Scenedesmus,	0	0	100	0	0
Staurastrum,	0	0	100	0	0
Fungi, Crenothrix,	1	0	0	1	5
ANIMALS.					
Infusoria,	0	563	0	0	4
Cryptomonas,	0	0	0	0	4
Dinobryon,	0	3	0	0	0
Dinobryon cases,	0	560	0	0	0
Miscellaneous, Zoöglœa,	0	0	150	19	0
TOTAL,	5	569	24,350	23	11

HINGHAM.

Chemical Examination of Water from Accord Brook, Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11662	Jan. 18	V. slight.	V. slight.	1.70	6.50	3.45	.0004	.0128	.0120	.0008	.71	.0070	.0000	1.4868	0.9
12320	June 5	V. slight.	Slight.	4.70	7.30	4.80	.0006	.0318	.0286	.0032	.56	.0050	.0000	2.7335	0.8

Odor, vegetable. —— The samples were collected from Accord Brook, which flows from Accord Pond, at the point where it crosses South Pleasant Street.

Microscopical Examination.

No. 11662. Diatomaceæ, *Meridion*, 3; *Synedra*, 2. Total, 5.
No. 12320. Diatomaceæ, *Diatoma*, 5; *Tabellaria*, 2. Fungi, *Crenothrix*, 5. Total, 12.

Chemical Examination of Water from Various Sources in Hingham, collected during an Investigation for an Additional Water Supply for Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11663	Jan. 18	V. slight.	Cons., rusty.	0.10	4.40	1.10	.0000	.0034	.0004	.0030	.65	.0280	.0000	.1098	1.3
12318	June 5	V. slight.	Slight.	2.50	5.65	2.85	.0038	.0248	.0238	.0010	.63	.0050	.0000	1.5862	0.9
12319	June 5	V. slight.	V. slight.	2.80	5.70	3.05	.0008	.0398	.0280	.0118	.52	.0030	.0000	1.9712	0.8
12344	June 11	–	–	1.25	9.60	–	–	–	–	–	.79	–	–	–	–

Odor of the first three samples, faintly vegetable. —— The first sample was collected from the brook which feeds Fulling Mill Pond; the second, from the brook flowing into Cushing Pond, just above the pond; the third, from Cushing Pond, near the dam and 2 feet below the surface; and the last, from a small pond made by damming Fresh River a short distance above the point where it crosses the New York, New Haven & Hartford Railroad, close to the boundary between Hingham and Weymouth.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 11663, 29; No. 12318, 80; No. 12319, 240; No. 12344, 820.

HINSDALE.

Water Supply of Hinsdale Fire District, Hinsdale.

Chemical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
12272	May 22	V. slight.	Slight.	0.28	2.15	1.25	.0000	.0186	.0126	.0060	.03	.0000	.0000	.3549	0.2
12437	June 26	Distinct, yellow.	Slight, green.	0.28	2.60	1.15	.0002	.0228	.0130	.0098	.06	.0000	.0000	.3627	0.8
12602	July 24	Decided, green.	Slight, green.	0.40	3.60	–	.0000	.0242	.0162	.0080	.08	.0000	.0001	.5659	0.9
12992	Sept. 19	Decided, green.	Cons., green.	0.55	3.50	2.25	.0000	.0326	.0166	.0160	.09	.0000	.0003	.5505	0.0
13156	Oct. 17	Decided, green.	Cons.	0.60	4.00	2.60	.0000	.0362	.0162	.0200	.10	.0000	.0000	.7623	0.8
13358	Nov. 21	Decided, green.	Slight, green.	0.40	3.10	1.75	.0000	.0276	.0132	.0144	.10	.0030	.0000	.4953	0.3
13526	Dec. 19	Distinct, green.	Slight, green.	0.20	3.00	1.60	.0006	.0178	.0118	.0060	.07	.0030	.0000	.3850	0.5
Av.	....	....	....	0.39	3.06*	1.77	.0001	.0257	.0142	.0115	.08	.0009	.0001	.4967	0.5

* Exclusive of No. 12602.

Odor of the first sample, distinctly oily, becoming decidedly vegetable and unpleasant on heating; of the second sample, distinct; of the third sample, distinctly fragrant; of the fourth and fifth, very faintly vegetable; of the sixth, faintly vegetable and mouldy; of the last, none. The odor of all samples was stronger on heating.—— The first three samples were collected from a faucet, and the others from the reservoir.

Microscopical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.

[Number of organisms per cubic centimeter.]

	1894. May.	July.	July.	Sept.	Oct.	Nov.	Dec.
Day of examination,	24	2	25	21	18	22	20
Number of sample,	12272	12437	12602	12992	13156	13358	13526
PLANTS.							
Diatomaceæ,	**36**	**0**	**0**	**0**	**13**	**0**	**0**
Asterionella,	28	0	0	0	0	0	0
Denticula,	0	0	0	0	4	0	0
Melosira,	0	0	0	0	5	0	0
Synedra,	5	0	0	0	0	0	0
Tabellaria,	3	0	0	0	4	0	0

HINSDALE.

Microscopical Examination of Water from the Storage Reservoir of the Hinsdale Fire District — Concluded.

[Number of organisms per cubic centimeter.]

	1894.						
	May.	July.	July.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.							
Cyanophyceæ, Chroöcoccus,	0	0	0	4	0	0	0
Algæ,	0	0	60	0	292	1,000	520
Closterium,	0	0	60	0	0	0	0
Palmella,	0	0	0	0	288	1,000	520
Zoöspores,	0	0	0	0	4	0	0
Fungi, Crenothrix,	5	0	0	0	1	0	0
ANIMALS.							
Rhizopoda, Arcella,	0	0	0	28	0	0	0
Infusoria,	652	39	5	0	90	0	0
Ciliated infusorian,	0	0	0	0	14	0	0
Dinobryon cases,	600	0	0	0	0	0	0
Euglena,	1	0	0	0	6	0	0
Monas,	0	0	1	0	7	0	0
Peridinium,	48	37	4	0	48	0	0
Phacus,	0	1	0	0	7	0	0
Trachelomonas,	3	1	0	0	8	0	0
Vermes,	0	0	1	8	9	1	0
Anurea,	0	0	1	8	1	1	0
Polyarthra,	0	0	0	0	4	0	0
Rotatorian ova,	0	0	0	0	1	0	0
Rotifer,	0	0	0	0	3	0	0
Miscellaneous, Zoöglœa,	220	80	0	12	0	0	0
TOTAL,	913	119	66	52	405	1,001	520

WATER SUPPLY OF HOLBROOK.

(See *Randolph*.)

HOLDEN.

Several samples of water were collected from sources in Holden during the investigations for a metropolitan water supply, and the analyses may be found tabulated under the head of "Nashua River," in the next chapter.

HOLLISTON.

Water Supply of Holliston. — Holliston Water Company.

Chemical Examination of Water from the Well of the Holliston Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11614	Jan. 9	None.	None.	0.10	4.15	.0000	.0036	.34	.0200	.0001	.0842	1.8	.0275
12009	April 9	None.	None.	0.05	3.35	.0002	.0032	.30	.0300	.0000	.1104	1.7	.0100
12555	July 17	V.slight.	V.slight.	0.20	4.40	.0000	.0044	.32	.0120	.0001	.0808	2.1	.0325
13101	Oct. 9	V.slight, milky.	None.	0.05	6.50	.0000	.0026	.30	.0000	.0000	.0266	3.8	.0170
Av.	....	....	....	0.10	4.60	.0001	.0035	.32	.0155	.0001	.0755	2.4	.0218

Odor of the first three samples, none; of the last, very faintly unpleasant. The odor of the first sample was very faintly vegetable on heating. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination of Water from the Well of the Holliston Water Company.

[Number of organisms per cubic centimeter.]

	1894. January.	1894. April.	1894. July.	1894. October.
Day of examination,	10	11	18	10
Number of sample,	11614	12009	12555	13101
PLANTS.				
Diatomaceæ,	0	14	0	0
Fragilaria,	0	4	0	0
Melosira,	0	10	0	0
Fungi, Crenothrix,	0	15	1	0
Miscellaneous, Zoöglœa,	3	0	80	0
Total,	3	29	81	0

WATER SUPPLY OF HOLYOKE.

The advice of the State Board of Health to the city of Holyoke, with regard to Munn Brook in the town of Granville as a source of additional water supply for the city, may be found on pages 20 and 21 of this volume.

Chemical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11678	Jan. 24	V. slight.	V. slight.	0.15	5.10	1.30	.0000	.0164	.0132	.0032	.17	.0150	.0001	.3673	3.0
11932	Mar. 21	Slight.	Slight.	0.18	4.25	1.15	.0000	.0214	.0118	.0096	.16	.0020	.0000	.3160	2.6
12279	May 23	Distinct.	Slight.	0.30	5.00	1.35	.0000	.0210	.0148	.0062	.12	.0030	.0000	.3744	2.6
12595	July 23	V. slight.	V. slight.	0.23	5.50	1.50	.0010	.0190	.0166	.0024	.16	.0030	.0001	.3696	3.1
13015	Sept. 24	Slight.	Cons., earthy.	0.45	5.95	1.25	.0016	.0290	.0218	.0072	.18	.0000	.0000	.3696	3.4
13403	Nov. 27	V. slight.	Slight.	0.30	4.40	1.20	.0018	.0154	.0144	.0010	.16	.0170	.0000	.2091	2.5
Av.	....	....	....	0.27	5.03	1.29	.0007	.0204	.0155	.0049	.16	.0067	.0000	.3343	2.9

Averages by Years.

From Brook before Reservoir was built.

-	1887*	-	-	0.48	7.89	1.44	.0024	.0204	-	-	.13	.0126	-	-	-
-	1888	-	-	0.25	6.63	1.22	.0009	.0183	-	-	.10	.0081	.0001	-	-
-	1889†	-	-	0.14	6.72	1.02	.0006	.0134	.0092	.0042	.11	.0054	.0001	-	-

From Reservoir.

-	1890‡	-	-	0.30	6.95	1.60	.0008	.0244	.0188	.0056	.15	.0120	.0000	-	3.6
-	1891	-	-	0.41	6.34	2.05	.0125	.0311	.0253	.0058	.12	.0185	.0006	-	3.1
-	1892	-	-	0.30	5.57	1.86	.0029	.0294	.0247	.0047	.14	.0192	.0001	-	2.8
-	1893	-	-	0.18	4.67	1.63	.0008	.0251	.0183	.0068	.13	.0063	.0001	.3838	2.5
-	1894	-	-	0.27	5.03	1.29	.0007	.0204	.0155	.0049	.16	.0067	.0000	.3343	2.9

* June to December. † January to May. ‡ December.

NOTE to analyses of 1894: Odor, generally vegetable; on one occasion disagreeable. —— The samples were collected from the reservoir.

HOLYOKE.

Microscopical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Number of organisms per cubic centimeter.]

	1894.					
	Jan.	March.	May.	July.	Sept.	Nov.
Day of examination,	25	23	25	24	25	30
Number of sample,	11678	11932	12279	12595	13015	13403
PLANTS.						
Diatomaceæ,	1	1,120	165	8	12	93
Asterionella,	1	1,120	5	7	12	5
Fragilaria,	0	0	0	0	0	84
Synedra,	0	pr.	160	1	0	4
Cyanophyceæ, Anabæna,	0	0	0	140	25	0
Algæ,	0	23	24	2	584	2
Chlorococcus,	0	3	0	0	56	0
Protococcus,	0	0	20	0	96	0
Scenedesmus,	0	0	0	0	432	2
Staurastrum,	0	0	4	1	0	0
Zoöspores,	0	20	0	1	0	0
Fungi, Crenothrix,	0	3	0	5	11	0
ANIMALS.						
Rhizopoda, Arcella,	0	0	0	0	5	0
Infusoria,	75	2,258	89	4	40	14
Dinobryon cases,	0	2,000	88	0	0	0
Euglena,	0	150	1	0	0	12
Monas,	0	0	0	1	0	0
Peridinium,	74	108	0	1	0	1
Phacus,	0	0	0	1	0	0
Trachelomonas,	1	0	0	1	40	1
Vermes,	0	2	3	0	1	0
Anurea,	0	0	1	0	1	0
Polyarthra,	0	2	0	0	0	0
Rotatorian ova,	0	0	1	0	0	0
Rotifer,	0	0	1	0	0	0
Miscellaneous, Zoöglœa,	1	0	0	23	32	0
TOTAL,	77	3,406	281	182	710	109

HOLYOKE.

Chemical Examination of Water from Wright and Ashley Ponds, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11677	Jan. 24	Slight, green.	Slight.	0.10	4.80	1.65	.0036	.0388	.0306	.0082	.23	.0050	.0001	.3752	2.6
11931	Mar. 21	Slight, clayey.	Slight.	0.05	5.05	1.00	.0014	.0136	.0092	.0044	.14	.0100	.0000	.2054	3.2
12278	May 23	V. slight.	Slight.	0.08	5.50	1.15	.0018	.0184	.0160	.0024	.15	.0030	.0000	.2184	2.9
12594	July 23	V. slight.	V. slight.	0.08	5.15	1.40	.0000	.0200	.0184	.0016	.18	.0020	.0000	.3142	3.1
13014	Sept. 24	V. slight.	Cons., sand.	0.15	5.15	1.35	.0014	.0218	.0190	.0028	.18	.0000	.0000	.2156	2.7
13402	Nov. 28	V. slight.	Slight.	0.10	5.20	1.45	.0048	.0166	.0140	.0026	.16	.0070	.0001	.2378	3.0
Av.	....	....	....	0.09	5.14	1.33	.0022	.0215	.0179	.0036	.17	.0045	.0000	.2611	2.9

Averages by Years.

–	1887*	–	–	0.08	5.25	0.89	.0029	.0202	–	–	.13	.0016	–	–	–
–	1888	–	–	0.06	4.81	0.82	.0024	.0178	–	–	.12	.0054	.0001	–	–
–	1889	–	–	0.02	5.37	0.74	.0020	.0201	.0161	.0040	.13	.0039	.0000	–	–
–	1890	–	–	0.01	–	–	.0020	.0201	.0151	.0050	.13	.0048	.0000	–	–
–	1891†	–	–	0.01	6.10	–	.0046	.0243	.0201	.0042	.13	.0035	.0001	–	2.9
–	1892‡	–	–	0.02	5.10	1.15	.0008	.0196	.0154	.0042	.17	.0020	.0000	–	3.1
–	1893	–	–	0.06	4.71	1.21	.0026	.0195	.0152	.0043	.15	.0072	.0000	.2466	3.1
–	1894	–	–	0.09	5.14	1.33	.0022	.0215	.0179	.0036	.17	.0045	.0000	.2611	2.9

* June to December. † July and October. ‡ May.

NOTE to analyses of 1894: Odor, generally faintly vegetable, becoming much stronger and generally unpleasant or grassy on heating. —— The samples were collected from Ashley Pond.

HOLYOKE.

Microscopical Examination of Water from Wright and Ashley Ponds, Holyoke.

[Number of organisms per cubic centimeter.]

	1894.					
	Jan.	March.	May.	July.	Sept.	Nov.
Day of examination,	25	23	24	24	25	30
Number of sample,	11677	11931	12278	12594	13014	13402
PLANTS.						
Diatomaceæ,	961	464	114	50	27	1,236
Asterionella,	960	150	0	5	4	500
Cyclotella,	0	6	3	0	4	5
Diatoma,	0	0	1	2	0	0
Fragilaria,	0	21	0	41	16	5
Melosira,	0	78	40	0	0	720
Stephanodiscus,	0	0	0	0	0	4
Synedra,	1	200	68	2	3	1
Tabellaria,	0	9	2	0	0	1
Cyanophyceæ,	0	0	0	9	55	0
Anabæna,	0	0	0	5	30	0
Chroöcoccus,	0	0	0	0	15	0
Clathrocystis,	0	0	0	3	0	0
Microcystis,	0	0	0	1	10	0
Algæ,	17	1	2	10	12	22
Cosmarium,	17	0	0	0	0	0
Protococcus,	0	0	2	0	0	18
Raphidium,	0	1	0	10	12	4
Fungi, Crenothrix,	4	0	0	0	0	0
ANIMALS.						
Rhizopoda, Actinophrys,	0	1	0	0	0	0
Infusoria,	361	122	126	4	3	13
Ceratium,	0	0	0	1	2	0
Dinobryon,	0	86	25	0	0	0
Dinobryon cases,	0	28	100	2	0	11
Euglena,	1	0	0	0	0	0
Mallomonas,	0	2	0	0	0	0
Peridinium,	360	2	1	1	0	0
Trachelomonas,	0	4	0	0	1	2
Vermes,	2	2	0	1	0	0
Polyarthra,	2	1	0	1	0	0
Rotifer,	0	1	0	0	0	0
Miscellaneous, Zoöglœa,	0	0	0	80	24	0
TOTAL,	1,345	590	242	154	121	1,271

WATER SUPPLY OF HUDSON.

Chemical Examination of Water from Gates Pond, Berlin.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11611	Jan. 9	V. slight.	V. slight.	0.05	2.45	0.80	.0058	.0130	.0102	.0028	.25	.0020	.0000	.1927	0.6
11708	Feb. 5	V. slight.	V. slight.	0.02	2.30	0.90	.0032	.0120	.0102	.0018	.21	.0000	.0000	.1280	0.5
11845	Mar. 6	V. slight.	Slight.	0.01	1.80	0.60	.0048	.0120	.0106	.0014	.16	.0030	.0000	.1760	0.2
11989	Apr. 2	Slight.	Cons.	0.03	2.10	0.60	.0026	.0142	.0114	.0028	.21	.0030	.0000	.1309	0.8
12202	May 14	Slight.	Slight.	0.05	2.05	0.70	.0006	.0146	.0120	.0026	.20	.0000	.0000	.1373	0.5
12322	June 6	Slight.	V. slight.	0.03	2.50	0.95	.0006	.0158	.0132	.0026	.22	.0000	.0000	.1525	0.9
12529	July 13	Slight.	Slight.	0.03	2.45	1.25	.0000	.0132	.0122	.0010	.26	.0000	.0000	.1070	0.5
12700	Aug. 9	Distinct.	Slight.	0.08	2.35	1.00	.0004	.0182	.0150	.0032	.20	.0000	.0000	.1332	0.7
12917	Sept. 11	Distinct.	Slight.	0.05	2.65	0.90	.0004	.0172	.0142	.0030	.19	.0020	.0000	.1386	0.6
13103	Oct. 9	Slight.	Slight, green.	0.05	2.25	0.85	.0000	.0164	.0130	.0034	.24	.0000	.0000	.1254	0.5
13309	Nov. 14	Slight.	Slight, green.	0.05	2.10	0.70	.0000	.0140	.0116	.0024	.22	.0000	.0000	.1677	0.6
13506	Dec. 18	V. slight.	V. slight.	0.08	2.25	0.75	.0006	.0168	.0152	.0016	.23	.0000	.0000	.1525	0.8
Av.	....	....	....	0.04	2.27	0.83	.0016	.0148	.0124	.0024	.22	.0008	.0000	.1452	0.6

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Alb. Total.	Alb. Dissolved.	Alb. Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
–	1887*	–	–	0.06	3.17	0.71	.0014	.0150	–	–	.21	.0054	–	–	–
–	1888	–	–	0.06	2.55	0.69	.0015	.0158	–	–	.19	.0055	.0001	–	–
–	1889	–	–	0.03	2.14	0.58	.0020	.0189	.0139	.0050	.19	.0048	.0001	–	–
–	1890	–	–	0.02	2.82	1.04	.0023	.0161	.0124	.0037	.21	.0054	.0000	–	1.2
–	1891	–	–	0.04	2.52	0.90	.0011	.0150	.0117	.0033	.20	.0074	.0000	–	0.9
–	1893	–	–	0.05	2.45	1.01	.0040	.0178	.0146	.0032	.23	.0039	.0000	.1965	0.6
–	1894	–	–	0.04	2.27	0.83	.0016	.0148	.0124	.0024	.22	.0008	.0000	.1452	0.6

* June to December.

NOTE to analyses of 1894: Until October the odor was generally faintly vegetable; in May the odor was distinctly oily on heating; in the last three samples the odor was much stronger and unpleasant or disagreeable. —— The samples were collected from the pond.

HUDSON.

Microscopical Examination of Water from Gates Pond, Berlin.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	10	5	7	5	15	7	14	10	12	10	15	20
Number of sample,	11611	11708	11845	11989	12202	12322	12529	12700	12917	13103	13309	13506
PLANTS.												
Diatomaceæ,	**1**	**0**	**14**	**564**	**48**	**22**	**13**	**20**	**15**	**128**	**701**	**1**
Asterionella,	0	0	14	360	46	0	0	0	0	47	240	0
Fragilaria,	0	0	0	0	0	0	0	0	0	3	10	0
Melosira,	0	0	0	204	1	2	6	20	2	24	350	0
Synedra,	0	0	0	pr.	1	0	0	0	3	4	80	1
Tabellaria,	1	0	0	pr.	pr.	20	7	0	10	50	21	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**1**	**67**	**6**	**48**	**80**	**5**	**0**	**0**
Anabæna,	0	0	0	0	0	54	2	0	0	1	0	0
Aphanocapsa,	0	0	0	0	0	4	0	0	80	4	0	0
Merismopedia,	0	0	0	0	0	0	0	20	0	0	0	0
Microcystis,	0	0	0	0	1	9	4	28	0	0	0	0
Algæ,	**0**	**0**	**0**	**76**	**93**	**187**	**5**	**10**	**2**	**11**	**10**	**0**
Arthrodesmus,	0	0	0	2	3	7	0	0	0	0	0	0
Chlorococcus,	0	0	0	0	0	4	4	0	0	8	4	0
Protococcus,	0	0	0	74	30	156	0	10	0	0	0	0
Raphidium,	0	0	0	0	60	20	0	0	0	0	5	0
Staurastrum,	0	0	0	0	0	0	1	0	2	3	1	0
Fungi, Molds,	**0**	**0**	**0**	**50**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.												
Rhizopoda, Difflugia,	**1**	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	3
Infusoria,	**65**	**7**	**7**	**20**	**103**	**10**	**16**	**15**	**22**	**46**	**12**	**2**
Dinobryon,	4	pr.	0	0	0	0	0	0	12	0	0	0
Dinobryon cases,	58	2	4	0	100	1	16	0	0	28	7	2
Mallomonas,	0	0	0	10	pr.	0	0	0	0	pr.	0	0
Monas,	0	pr.	0	0	0	0	pr.	0	1	16	0	0
Peridinium,	2	4	3	8	pr.	2	pr.	15	9	1	3	0
Trachelomonas,	1	1	pr.	2	pr.	0	pr.	0	0	1	2	0
Vorticella,	0	0	0	0	3	7	0	0	0	pr.	0	0
Vermes,	**0**	**0**	**pr.**	**0**	**1**	**1**	**0**	**2**	**1**	**0**	**1**	**0**
Anuræa,	0	0	0	0	0	1	0	0	0	0	1	0
Polyarthra,	0	0	pr.	0	0	0	0	1	1	0	0	0
Rotatorian ova,	0	0	0	0	1	0	0	1	0	0	0	0
Miscellaneous, Zoöglœa,	**0**	**1**	**0**	**32**	**0**	**40**	**40**	**60**	**11**	**126**	**0**	**0**
TOTAL,	67	8	21	742	246	327	80	155	131	316	724	6

HUDSON.

Table showing Heights of Water in Gates Pond once Each Month during 1894.

[High-water mark is 14 feet.]

Date. — 1894.	Feet.	Date. — 1894.	Feet.
Jan. 15,	10.7	July 15,	10.7
Feb. 15,	11.0	Aug. 15,	10.1
March 15,	11.4	Sept. 15,	9.3
April 15,	11.7	Oct. 15,	8.9
May 15,	11.6	Nov. 15,	8.9
June 15,	11.7	Dec. 15,	8.8

Water Supply of Hull.

(See *Hingham.*)

Water Supply of Hyde Park and Milton. — Hyde Park Water Company.

The replies of the State Board of Health to inquiries of the school committee of Hyde Park with reference to the quality of the water supplied by the Hyde Park Water Company may be found on pages 21–23 of this volume.

The works of this company for obtaining a supply of water from the ground near the Neponset River were again enlarged in 1894 by sinking 6 tubular wells north-east of the starch factory well mentioned in previous reports. The new wells are located in a line nearly parallel and very close to the southerly side of the location of the New York & New England Railroad, and average about 45 feet apart in the line. The wells are 6 inches in diameter and vary very little in depth, averaging about 40 feet. The well at the south-westerly end of the line is 350 feet from the river, and that on the north-easterly end of the line about 250 feet from the river. Owing to a sharp bend in the river at this point, the intermediate wells are more distant from it than those on the ends. Each well is said to be provided with a strainer from 10 to 14 feet in length, making the distance from the surface to the point where water may enter the well about 25 feet. The advice of the State Board of Health to the Hyde Park Water Company with reference to the use of water from these wells may be found on pages 23 and 24 of this volume. (See also *Milton.*)

HYDE PARK.

Chemical Examination of Water from the Wells of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11628	Jan. 9	None.	None.	0.00	8.90	.0026	.0010	1.26	.0850	.0004	.0647	3.8	.0070
11760	Feb. 14	None.	None.	0.00	9.10	.0000	.0078	1.18	.1200	.0002	.0680	3.8	.0150
11873	Mar. 9	V. slight.	V. slight.	0.04	7.30	.0078	.0042	0.99	.0780	.0001	.0696	3.0	.0490
12061	April 17	None.	None.	0.00	8.65	.0012	.0014	1.03	.0850	.0000	.0546	3.4	.0075
12221	May 15	None.	None.	0.00	8.45	.0016	.0024	0.99	.1000	.0000	.0663	3.4	.0040
12396	June 19	None.	None.	0.05	8.70	.0008	.0014	1.05	.0600	.0000	.0947	3.5	.0040
12565	July 17	None.	None.	0.04	9.00	.0026	.0030	1.23	.1000	.0000	.1140	3.5	.0090
12736	Aug. 13	None.	None.	0.05	11.80	.0044	.0064	1.32	.1000	.0000	.0924	4.3	.0150
12966	Sept. 17	Slight.	Cons.	0.05	13.00	.0058	.0080	1.90	.0950	.0000	.1232	4.6	.0300
13134	Oct. 15	Slight.	Slight.	0.08	11.40	.0090	.0048	2.05	.0680	.0001	.1303	4.9	.0290
13345	Nov. 19	V. slight.	Cons., dark.	0.03	10.00	.0058	.0032	1.74	.0700	.0000	.1053	4.0	.0270
13493	Dec. 17	None.	Slight.	0.01	9.80	.0066	.0032	1.69	.0500	.0001	.0731	4.4	.0140
Av.	....	....	....	0.03	9.68	.0040	.0039	1.37	.0843	.0001	.0880	3.9	.0175

Averages by Years.

–	1887*	–	–	0.00	6.67	.0004	.0012	0.82	.0699	–	–	–	–
–	1888	–	–	0.00	6.06	.0001	.0023	0.75	.0641	.0002	–	–	–
–	1889†	–	–	0.00	5.76	.0001	.0019	0.68	.0596	.0001	–	–	–
–	1890‡	–	–	0.02	9.35	.0006	.0023	0.88	.0550	.0002	–	4.2	–
–	1891§	–	–	0.03	9.10	.0000	.0040	0.96	.0675	.0002	–	3.6	–
–	1892‖	–	–	0.00	7.20	.0004	.0035	0.99	.0500	.0004	–	3.0	–
–	1893	–	–	0.02	8.62	.0031	.0032	1.19	.0879	.0002	.0976	3.7	.0112
–	1894	–	–	0.03	9.68	.0040	.0039	1.37	.0843	.0001	.0880	3.9	.0175

* June to December. † January to May. ‡ February and August.
§ June and September. ‖ Two samples in July.

NOTE to analyses of 1894: Odor, until September, none; in September, distinctly mouldy; in October, very faintly musty; in November, faintly vegetable; in December, faintly earthy. On heating, a very faintly mouldy odor was developed in the sample collected in February, and the odor of the last four samples was less strong or disappeared. —— The samples were collected from a faucet at the pumping station.

HYDE PARK.

Microscopical Examination of Water from the Wells of the Hyde Park Water Company.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, .	11	15	13	18	16	22	18	15	18	17	22	18
Number of sample, .	11628	11760	11873	12061	12221	12396	12565	12736	12966	13134	13345	13493
PLANTS.												
Fungi, Crenothrix, .	0	0	106	70	10	5	0	0	708	32	54	70
Miscellaneous, Zoöglœa, .	0	0	18	0	0	0	0	0	236	22	0	0
TOTAL, ...	0	0	124	70	10	5	0	0	944	54	54	70

Chemical Examination of Water from Faucets in Hyde Park supplied from the Wells of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
13037	Sept. 27	None.	None.	0.05	11.70	.0056	.0042	2.30	.1000	.0004	.0680	4.2	.0050
13038	Sept. 27	V. slight.	Slight, brown.	0.05	12.00	.0036	.0040	2.30	.1000	.0002	.0704	4.3	.0300
13039	Sept. 27	None.	None.	0.05	12.10	.0004	.0034	2.30	.1000	.0000	.0920	4.7	.0100

Odor of the first sample, very faintly mouldy; of the other two, none. —— The first sample was collected from a faucet at Frost's Pharmacy; the second from a faucet inside the post-office building at Clarendon Hills; and the last from a faucet in a house on Business Street.

Microscopical Examination.

No. 13037. Fungi, *Crenothrix*, 1. Miscellaneous, *Zoöglœa*, 3. Total, 4.
No. 13038. Fungi, *Crenothrix*, 168.
No. 13039. Miscellaneous, *Zoöglœa*, 6.

HYDE PARK.

Chemical Examination of Water from a Faucet in Milton, supplied from the Wells of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11617	Jan. 9	None.	None.	0.00	8.45	.0006	.0016	1.27	.1050	.0000	.0320	3.4	.0025
11720	Feb. 6	None.	None.	0.00	9.10	.0000	.0026	1.20	.0980	.0000	.0640	3.6	.0000
11885	Mar. 13	None.	None.	0.00	8.10	.0000	.0020	1.04	.0900	.0000	.0440	3.0	.0070
12008	April 9	None.	None.	0.00	6.40	.0000	.0014	1.03	.0800	.0000	.0320	3.0	.0050
12168	May 8	None.	V. slight.	0.03	7.50	.0000	.0012	0.97	.1200	.0000	.0590	3.0	.0320
12354	June 12	None.	None.	0.02	9.00	.0000	.0028	1.05	.0750	.0000	.0346	3.2	.0160
12515	July 11	None.	None.	0.02	8.00	.0000	.0030	1.11	.0750	.0000	.0716	3.3	.0090
12733	Aug. 13	None.	None.	0.08	9.80	.0004	.0032	1.38	.1140	.0000	.0577	3.7	.0100
12908	Sept. 10	None.	None.	0.02	10.20	.0000	.0026	1.67	.1000	.0000	.0154	4.0	.0050
13093	Oct. 8	None.	None.	0.01	12.20	.0000	.0042	2.36	.0500	.0001	.0722	4.4	.0020
13269	Nov. 7	None.	None.	0.02	10.60	.0006	.0052	2.52	.0800	.0001	.0577	4.2	.0050
13410	Dec. 3	None.	None.	0.00	9.40	.0002	.0022	1.89	.0780	.0000	.0577	3.8	.0100
Av.	....	....	....	0.02	9.06	.0002	.0027	1.46	.0888	.0000	.0498	3.6	.0086

Odor, none, except in November, when it was distinctly musty. In January the odor was faintly vegetable on heating, and in October distinctly mouldy. —— The samples were collected from a faucet in the office of the Milton Water Company.

Microscopical Examination of Water from a Faucet in Milton, supplied from the Wells of the Hyde Park Water Company.

[Number of organisms per cubic centimeter.]

	1894. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	10	7	14	10	9	14	12	14	12	9	8	3
Number of sample, . .	11617	11720	11885	12008	12168	12354	12515	12733	12908	13093	13269	13410
PLANTS.												
Diatomaceæ, Melosira,	0	0	0	8	0	0	0	0	0	0	0	0
Fungi, Crenothrix, . .	0	600	92	34	760	52	152	0	0	0	0	4
Miscellaneous, Zoöglœa, .	0	0	1	24	0	4	0	0	0	0	0	0
TOTAL, ...	0	600	93	66	760	56	152	0	0	0	0	4

HYDE PARK.

Chemical Examination of Water from the New Six-inch Tubular Wells of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1894.												
12380	June 14	None.	None.	0.00	4.85	.0000	.0004	0.66	.0700	.0000	.0115	1.6	.0000
12450	June 30	None.	None.	0.01	6.10	.0000	.0000	0.70	.0630	.0000	.0000	2.7	.0080
12530	July 13	None.	Slight.	0.02	8.10	.0004	.0010	0.78	.1200	.0000	.0000	2.3	.0090
12588	July 20	None.	None.	0.04	8.30	.0016	.0000	1.03	.1500	.0000	.0000	2.9	.0050
12630	July 30	None.	V. slight.	0.00	8.20	.0000	.0008	1.18	.1500	.0002	.0323	2.2	.0040
12642	July 31	None.	None.	0.03	15.20	.0000	.0000	1.19	.4000	.0002	.0015	5.0	.0030
12668	Aug. 7	None.	None.	0.00	9.30	.0000	.0014	1.42	.0800	.0003	.0231	3.4	.0050
12735	Aug. 13	None.	None.	0.02	12.30	.0000	.0034	1.50	.2200	.0008	.0308	3.0	.0230
12791	Aug. 20	V. slight.	Slight.	0.02	11.50	.0004	.0022	1.72	.2000	.0010	.0308	3.5	.0030
12829	Aug. 27	None.	V. slight.	0.03	13.50	.0000	.0016	1.90	.2000	.0014	.0154	3.8	.0140
12882	Sept. 4	V. slight.	Slight.	0.02	11.10	.0000	.0026	1.20	.2000	.0014	.0308	3.8	.0050
12959	Sept. 14	None.	None.	0.05	13.00	.0000	.0020	2.80	.0800	.0025	.0539	4.3	.0030
12990	Sept. 19	V. slight.	Slight.	0.05	12.90	.0000	.0040	2.61	.1650	.0023	.0423	3.8	.0050
13016	Sept. 24	V. slight.	None.	0.03	13.50	.0004	.0020	3.12	.0500	.0022	.0269	4.3	.0020
13035	Sept. 26	None.	None.	0.02	13.00	.0000	.0052	3.20	.0250	.0100	.0520	4.4	.0030
13248	Oct. 31	None.	V. slight.	0.01	12.80	.0004	.0060	2.91	.1050	.0008	.0731	4.3	.0010
13285	Nov. 8	None.	None.	0.00	11.60	.0002	.0028	2.75	.1100	.0008	.0741	4.0	.0030

Odor of No. 12630 and of Nos. 12668 to 12882, distinctly vinous; of No. 12990, distinctly vinous, becoming mouldy on standing; of Nos. 13016 to 13285, musty or mouldy. The odor of Nos. 13016 and 13248 became disagreeable on heating. The remaining samples had no odor. —— The wells are numbered in line from the south-west toward the north-east. The first sample was collected from well No. 2, the second from well No. 3, and the third from a tap on a pump drawing water from both of these wells just after a pumping test of about sixteen and one-half hours' duration had been made; Nos. 12588 and 12630 were also collected from a tap on the pump while pumping from these two wells; No. 12642 was collected from well No. 1; Nos. 12668 to 12882 and No. 12990 were collected while pumping from wells Nos. 1, 2 and 3; No. 12959 was collected from well No. 4; No. 13016 from well No. 5; No. 13035 from well No. 6. The remaining samples were collected from a faucet in the pumping station while pumping from the six wells together.

Microscopical Examination.

No. 12450. Miscellaneous, *Zoöglœa*, 5.
No. 12530. Miscellaneous, *Zoöglœa*, 24.
No. 12588. Fungi, *Crenothrix*, 54. Miscellaneous, *Zoöglœa*, 18. Total, 72.
No. 12791. Fungi, *Crenothrix*, 1. Miscellaneous, *Zoöglœa*, 7. Total, 8.
No. 12959. Miscellaneous, *Zoöglœa*, 3.
No. 12990. Fungi, *Crenothrix*, 9. Miscellaneous, *Zoöglœa*, 51. Total, 60.
No. 13016. Miscellaneous, *Zoöglœa*, 3.
No. 13035. Infusoria, *Peridinium*, 2. Miscellaneous, *Zoöglœa*, 2. Total, 4.
No organisms were found in the remaining samples.

HYDE PARK.

Chemical Examination of Water from the Neponset River at Hyde Park.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11627	Jan. 9	Slight.	Slight.	1.00	6.50	2.80	.0030	.0188	.0166	.0022	0.92	.0160	.0001	.8993	1.7
11759	Feb. 14	Distinct.	Slight.	0.90	6.30	2.15	.0018	.0228	.0208	.0020	0.99	.0180	.0001	.9584	1.8
11872	Mar. 9	V. slight.	Slight.	0.80	4.35	1.60	.0006	.0202	.0178	.0024	0.56	.0050	.0000	.7960	0.9
12060	Apr. 17	V. slight.	Slight, rusty.	0.90	4.45	1.80	.0008	.0206	.0192	.0014	0.65	.0000	.0000	.8580	1.3
12220	May 15	Distinct.	Cons.	1.60	10.55	3.35	.0104	.0432	.0354	.0078	1.82	.0030	.0001	1.2753	3.4
12395	June 19	Distinct.	Heavy, rusty.	2.00	10.40	2.80	.0056	.0428	.0346	.0082	1.50	.0030	.0000	1.2281	2.5
12564	July 17	Slight.	Cons., rusty.	0.90	12.00	2.50	.0064	.0334	.0226	.0108	2.59	.0030	.0001	.7839	4.0
12734	Aug. 13	V. slight.	Cons., green.	0.78	12.90	2.10	.0502	.0376	.0304	.0072	2.56	.0000	.0000	.6691	4.0
12965	Sept. 17	Decided.	Heavy, rusty.	0.65	20.25	4.00	.0384	.0976	.0498	.0478	4.06	.0000	.0001	.8624	7.0
13133	Oct. 15	Distinct.	Cons.	1.30	13.15	3.75	.0148	.0404	.0384	.0020	2.06	.0060	.0010	1.3114	4.4
13344	Nov. 19	Slight.	Cons.	1.50	8.50	3.05	.0020	.0278	.0240	.0038	1.10	.0080	.0002	1.3455	2.7
13492	Dec. 17	Slight.	Cons.	1.30	6.75	2.40	.0004	.0272	.0234	.0038	0.84	.0120	.0001	1.0164	2.1
Av.	....	....	....	1.14	9.68	2.69	.0112	.0360	.0277	.0083	1.64	.0062	.0002	1.0003	3.0

Averages by Years.

-	1887*	-	-	1.19	8.35	2.30	.0053	.0400	-	-	0.99	.0080	-	-	-
-	1888	-	-	1.02	6.77	2.27	.0030	.0324	-	-	0.83	.0095	.0002	-	-
-	1891†	-	-	1.48	10.34	3.45	.0190	.0510	.0413	.0097	1.16	.0065	.0003	-	3.3
-	1892‡	-	-	0.90	13.30	2.85	.0260	.0324	.0286	.0038	2.31	.0090	.0012	-	4.4
-	1893	-	-	1.16	7.70	2.49	.0151	.0320	.0254	.0066	1.19	.0154	.0005	.9548	2.4
-	1894	-	-	1.14	9.68	2.69	.0112	.0360	.0277	.0083	1.64	.0062	.0002	1.0003	3.0

* June to December. † August and September. ‡ July.

NOTE to analyses of 1894: Iron, .0222. Odor, decidedly musty or mouldy, and frequently also disagreeable. —— The samples were collected from the river, opposite the works of the Hyde Park Water Company. The river is not used directly as a source of water supply.

HYDE PARK.

Microscopical Examination of Water from the Neponset River at Hyde Park.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	11	15	13	18	16	22	18	15	18	17	22	18
Number of sample,	11627	11759	11872	12060	12220	12395	12564	12734	12965	13133	13344	13492
PLANTS.												
Diatomaceæ,	1	3	1	13	3	2	116	28	3	71	21	14
Melosira,	0	0	0	0	0	0	0	0	0	0	10	0
Navicula,	pr.	1	0	2	1	0	0	0	0	6	0	0
Synedra,	0	0	1	5	2	2	116	28	3	64	11	13
Tabellaria,	1	2	0	6	0	0	0	0	0	1	0	1
Cyanophyceæ, Oscillaria,	0	0	0	0	0	0	0	5	3	4	0	1
Algæ,	0	0	pr.	0	2	2	13	20	8	1	0	0
Closterium,	0	0	0	0	0	0	4	3	1	0	0	0
Conferva,	0	0	0	0	0	0	5	1	0	0	0	0
Protococcus,	0	0	pr.	0	0	0	0	10	0	0	0	0
Scenedesmus,	0	0	0	0	2	2	3	0	1	1	0	0
Selenastrum,	0	0	0	0	0	0	0	0	6	0	0	0
Spirogyra,	0	0	0	0	0	0	1	6	0	0	0	0
Fungi,	20	5	78	1	1,520	1,440	256	3	160	2	44	10
Crenothrix,	20	0	78	0	1,520	1,440	256	2	160	2	44	10
Molds,	0	5	pr.	1	0	0	0	1	0	0	0	0
ANIMALS.												
Rhizopoda, Arcella,	0	0	0	0	0	2	0	0	0	0	0	0
Infusoria,	3	6	3	2	5	14	3	1	32	2	1	0
Ciliated infusorian,	0	0	pr.	0	0	2	1	0	1	0	0	0
Cryptomonas,	0	0	0	0	1	0	0	0	4	0	0	0
Dinobryon,	3	4	pr.	0	0	0	0	0	0	0	0	0
Euglena,	0	0	0	0	0	4	0	0	15	1	0	0
Monas,	0	0	1	1	0	4	0	0	2	0	1	0
Paramæcium,	0	0	0	0	0	2	0	0	0	0	0	0
Peridinium,	pr.	2	2	1	2	0	0	1	4	0	0	0
Phacus,	0	0	0	0	0	0	0	0	5	0	0	0
Trachelomonas,	0	0	0	0	2	2	2	0	1	1	0	0
Vermes, Rotifer,	0	0	0	0	0	0	0	0	4	3	0	1
Miscellaneous, Zoöglœa,	22	36	30	17	156	2,080	1,240	2,160	2,240	780	92	92
TOTAL,	46	50	112	33	1,686	3,540	1,628	2,217	2,450	863	158	118

IPSWICH.

Water Supply of Ipswich.

The works are owned by the town, and were completed in the latter part of 1894. The source of supply is a storage reservoir on Dow's Brook, very near its junction with Bull Brook, to be supplemented when necessary with water from Bull Brook. The water is pumped at a pumping station near the reservoir to a distributing reservoir on Town Hill and to the village.

The storage reservoir has an area of about 17.5 acres and a capacity of about 55,000,000 gallons. Its maximum depth at high water is 20 feet and its average depth 9.6 feet. The reservoir was very thoroughly prepared for the storage of water by the removal of soil, mud and vegetable matter from the area to be flowed.

Dow's Brook has a water-shed of about 600 acres, consisting largely of pasture land, but there are several farmhouses in the vicinity of the reservoir, and, though the population per square mile is small, it may have a greater influence upon the quality of the water of the reservoir than if scattered more widely over the whole water-shed.

Bull Brook has a rapid fall for some distance above where it joins Dow's Brook, and at a point about 900 feet above the junction of the brooks a small dam has been constructed from which a 12-inch vitrified pipe has been laid to convey water from above this dam into the storage reservoir on Dow's Brook. The water-shed of Bull Brook above the dam contains but few inhabitants, but a large portion of the area is swampy land, causing the water to have a high color. By the construction of the dam a portion of this swampy land near the dam is said to be flowed.

The distributing reservoir is rectangular in shape, 180 feet long by 100 feet wide at the foot of the slopes, and about 237 feet by 157 feet at the top of the slopes inside. It is 19 feet in depth from the top of the embankment, and when filled to a depth of 16 feet contains a little more than 3,000,000 gallons of water. The slopes are lined with a 6-inch layer of coarse gravel, upon which is laid a stone paving about 12 inches in thickness. The bottom is covered with a 6-inch layer of concrete, which extends up beneath the gravel and paving on the slopes for a portion of the way, then horizontally to a masonry core wall in the embankment about the reservoir. Distributing mains are of cast iron, service pipes are of lead.

IPSWICH.

The advice of the State Board of Health to the town of Ipswich relative to this source of water supply may be found on pages 24–26 of this volume.

Analyses of samples of water collected during the investigation for a water supply may be found on page 179 of the annual report for 1893.

Lakeville.

Analyses of samples of water collected from Assawompsett and Elder's ponds may be found under Taunton, and from Great Quittacas, Little Quittacas and Long ponds under New Bedford.

Water Supply of Lancaster.

The town of Lancaster purchased the works of the Lancaster Water Company in 1893, but still continues to obtain its supply of water from the Clinton Water Works.

Water Supply of Lawrence.

The city of Lawrence has been supplied during the year with the Merrimack River water filtered through the sand filter, first used in September, 1893, and fully described in the last annual report of the State Board of Health, pages 543–560. The tables which follow contain analyses of the unfiltered Merrimack River water, and of the filtered water at the pumping station and at the distributing reservoir. The results of more extended chemical and biological examinations of the water before and after filtration may be found in a subsequent portion of this report.

LAWRENCE.

Chemical Examination of Water from the Merrimack River above Lawrence, Opposite the Intake of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11647	Jan. 17	Slight.	Slight.	0.35	4.00	1.45	.0036	.0128	.0108	.0020	.24	.0090	.0002	.4835	1.3
11753	Feb. 14	Slight.	Slight.	0.30	3.95	1.30	.0064	.0148	.0136	.0012	.25	.0150	.0001	.4320	1.4
11893	Mar. 14	Distinct.	Cons., earthy.	0.55	2.85	1.10	.0010	.0178	.0160	.0018	.12	.0100	.0001	.5640	0.5
12055	Apr. 16	Distinct.	Slight.	0.42	3.50	1.35	.0018	.0154	.0128	.0026	.20	.0030	.0001	.4501	0.8
12232	May 16	Slight.	Cons.	0.48	3.35	1.00	.0054	.0172	.0142	.0030	.17	.0050	.0002	.4680	1.1
12406	June 20	Distinct.	Cons.	0.48	3.55	1.35	.0096	.0198	.0156	.0042	.19	.0030	.0001	.4605	1.3
12574	July 18	Distinct.	Slight.	0.30	3.00	1.00	.0082	.0160	.0132	.0028	.26	.0040	.0003	.4004	0.9
12760	Aug. 15	Distinct, green.	Slight, green.	0.25	3.95	1.35	.0106	.0176	.0144	.0032	.28	.0040	.0002	.2926	1.1
12995	Sept. 19	V. slight.	Cons.	0.18	4.00	1.15	.0104	.0156	.0122	.0034	.28	.0030	.0001	.2579	1.3
13164	Oct. 17	Slight, milky.	Slight, brown.	0.23	3.95	1.60	.0072	.0172	.0140	.0032	.22	.0040	.0000	.4463	1.4
13354	Nov. 21	Slight.	Slight.	0.50	4.45	1.65	.0056	.0184	.0160	.0024	.27	.0080	.0001	.5460	1.6
13523	Dec. 19	Slight.	Slight.	0.37	3.90	1.30	.0040	.0172	.0164	.0008	.25	.0070	.0001	.4427	1.4
Av.	....	....	....	0.37	3.70	1.30	.0062	.0167	.0141	.0026	.23	.0063	.0001	.4370	1.2

Averages by Years.

–	1887*	–	–	0.47	4.82	1.24	.0027	.0211	–	–	.22	.0097	–	–	–
–	1888	–	–	0.30	3.68	1.08	.0026	.0180	–	–	.18	.0094	.0002	–	–
–	1889	–	–	0.30	3.09†	0.87†	.0030	.0176	.0144	.0032	.17	.0072	.0003	–	–
–	1890	–	–	0.33	4.19‡	1.48‡	.0046	.0166	.0132	.0034	.17	.0089	.0001	–	1.6§
–	1891	–	–	0.27	3.79	1.32	.0040	.0152	.0121	.0031	.18	.0110	.0001	–	1.3
–	1892	–	–	0.43	4.12	1.47	.0042	.0181	.0152	.0029	.18	.0105	.0001	–	1.4
–	1893	–	–	0.42	3.86	1.48	.0057	.0181	.0141	.0040	.20	.0081	.0002	.5295	1.1
–	1894	–	–	0.37	3.70	1.30	.0062	.0167	.0141	.0026	.23	.0063	.0001	.4370	1.2

* June to November. † January to May. ‡ August to December. § July to December.

NOTE to analyses of 1894: Odor, vegetable and musty. — The samples were collected from the river, opposite the intake of the Lawrence water works, about 1 foot beneath the surface. For a record of the quantity of water flowing in the river on dates when samples of water were collected for analysis, see page 194. For a comparison of the analyses of the river water at Lowell and Lawrence for a series of years, see "Merrimack River" in the chapter on "Examination of Rivers."

LAWRENCE.

Microscopical Examination of Water from the Merrimack River above Lawrence, Opposite the Intake of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	15	15	18	17	22	19	16	21	18	22	20
Number of sample,	11647	11753	11893	12055	12232	12406	12574	12760	12995	13164	13354	13523
PLANTS.												
Diatomaceæ,	8	18	54	46	107	394	86	289	67	42	17	4
Asterionella,	0	0	5	16	14	4	0	1	1	0	3	0
Epithemia,	0	0	1	13	0	0	0	0	0	0	1	0
Fragilaria,	0	0	0	0	0	0	0	95	0	0	0	0
Melosira,	0	0	3	0	10	6	0	0	0	0	10	0
Navicula,	0	5	3	2	1	1	2	1	0	1	0	0
Synedra,	8	13	42	15	88	376	84	192	52	40	3	2
Tabellaria,	0	0	pr.	0	4	7	0	0	14	1	0	2
Cyanophyceæ, Chroöcoccus,	0	0	0	0	0	0	0	0	0	6	0	0
Algæ,	0	0	0	0	0	60	47	168	25	9	0	0
Chlorococcus,	0	0	0	0	0	0.	0	0	6	0	0	0
Hyalotheca,	0	0	0	0	0	0	30	0	1	0	0	0
Protococcus,	0	0	0	0	0	59	0	168	0	0	0	0
Raphidium,	0	0	0	0	0	0	0	0	0	8	0	0
Tetraspora,	0	0	0	0	0	0	16	0	0	0	0	0
Zoöspores,	0	0	0	0	0	1	1	0	18	1	0	0
Fungi, Crenothrix,	4	2	2	1	9	1	6	0	40	22	3	0
ANIMALS.												
Rhizopoda, Arcella,	0	0	pr.	0	0	1	0	0	2	0	0	0
Infusoria,	3	0	0	2	10	4	25	9	4	4	5	0
Dinobryon,	0	0	0	0	10	3	9	1	0	0	3	0
Dinobryon cases,	0	0	0	2	0	1	10	2	0	0	2	0
Monas,	3	0	0	0	0	0	0	3	4	2	0	0
Peridinium,	0	0	0	0	0	0	3	0	0	1	0	0
Tintinnidium,	0	0	0	0	0	0	0	2	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	1	0	1	0	0
Vorticella,	0	0	0	0	0	0	3	0	0	0	0	0
Vermes,	0	0	0	0	0	1	1	3	1	0	0	0
Anurea,	0	0	0	0	0	1	1	0	1	0	0	0
Rotifer,	0	0	0	0	0	0	0	3	0	0	0	0
Miscellaneous, Zoöglœa,	204	52	22	18	15	10	176	184	88	300	72	72
TOTAL,	219	72	78	67	141	471	341	653	227	383	97	76

LAWRENCE.

Chemical Examination of Filtered Water from the Force Main at the Pumping Station of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11648	Jan. 17	V. slight.	V. slight.	0.30	6.40	1.20	.0108	.0048	.0046	.0002	.32	.0400	.0003	.3271	3.1
11754	Feb. 14	None.	V. slight.	0.28	5.45	1.60	.0066	.0108	.0096	.0012	.30	.0280	.0001	.3880	2.2
11894	Mar. 14	V. slight.	V. slight.	0.48	5.95	1.25	.0116	.0118	.0104	.0014	.24	.0300	.0003	.3896	3.0
12057	Apr. 16	V. slight.	V. slight.	0.38	4.45	1.50	.0044	.0108	.0090	.0018	.21	.0120	.0000	.3705	1.7
12233	May 16	V. slight.	V. slight.	0.40	5.70	1.55	.0058	.0102	.0082	.0020	.26	.0300	.0001	.3182	2.1
12408	June 20	Distinct, milky.	Slight.	0.45	6.85	1.25	.0104	.0102	.0084	.0018	.29	.0350	.0002	.2579	3.2
12575	July 18	Slight, milky.	Slight.	0.12	6.50	1.60	.0106	.0092	.0080	.0012	.26	.0380	.0010	.2325	3.0
12761	Aug. 15	None.	V. slight.	0.25	6.90	1.45	.0060	.0054	.0054	.0000	.38	.0400	.0002	.1655	3.3
12996	Sept. 19	V. slight.	V. slight.	0.25	6.00	1.50	.0074	.0082	.0072	.0010	.35	.0380	.0000	.1463	2.9
13165	Oct. 17	V. slight.	V. slight.	0.40	6.05	1.30	.0116	.0082	.0070	.0012	.37	.0300	.0000	.2425	3.0
13355	Nov. 21	V. slight.	V. slight.	0.73	6.95	1.40	.0176	.0098	.0080	.0018	.36	.0300	.0001	.3549	3.2
13524	Dec. 19	V. slight.	None.	0.60	6.05	1.30	.0208	.0132	.0116	.0016	.30	.0200	.0001	.2987	2.7
Av.	......	....	....	0.39	6.10	1.41	.0103	.0094	.0081	.0013	.30	.0309	.0002	.2910	2.8

Odor, generally vegetable, sometimes none.——The samples were collected from a faucet in the check-valve just beyond the pump, and represent water from the river which has passed through the sand filter, mingled with a small amount of ground water.

Microscopical Examination of Filtered Water from the Force Main at the Pumping Station of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1894. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	15	15	18	17	22	19	16	22	18	22	20
Number of sample,	11648	11754	11894	12057	12233	12408	12575	12761	12996	13165	13355	13524
PLANTS.												
Diatomaceæ, Synedra,	pr.	pr.	0	0	0	180	0	0	0	0	0	0
Fungi, Crenothrix,	2	2	3	28	320	76	66	120	60	78	856	48
Miscellaneous, Zoöglœa,	0	1	7	0	48	94	136	200	20	126	0	0
TOTAL,	2	3	10	28	368	350	202	320	80	204	856	48

LAWRENCE.

Chemical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11649	Jan. 17	V. slight.	V. slight.	0.33	5.00	1.35	.0028	.0062	.0054	.0008	.24	.0200	.0002	.3887	2.2
11755	Feb. 14	None.	V. slight.	0.25	5.25	1.55	.0028	.0110	.0088	.0022	.27	.0250	.0000	.3520	2.2
11895	Mar. 14	V. slight.	Slight.	0.30	5.05	1.15	.0028	.0104	.0088	.0016	.24	.0200	.0002	.3760	2.3
12056	Apr. 16	V. slight.	Slight.	0.30	5.05	1.25	.0018	.0094	.0076	.0018	.23	.0250	.0001	.3276	2.1
12234	May 16	V. slight.	Cons.	0.33	4.75	1.40	.0020	.0092	.0080	.0012	.19	.0280	.0000	.3471	2.2
12407	June 20	Slight.	Slight.	0.43	5.00	1.25	.0026	.0102	.0100	.0002	.22	.0280	.0000	.3896	1.9
12576	July 18	None.	V. slight.	0.15	4.50	1.40	.0030	.0096	.0084	.0012	.28	.0370	.0003	.2464	2.1
12762	Aug. 15	None.	V. slight.	0.15	5.05	1.15	.0014	.0076	.0074	.0002	.34	.0200	.0001	.1925	2.1
12997	Sept. 19	V. slight.	Slight.	0.10	5.25	1.40	.0014	.0092	.0078	.0014	.36	.0270	.0000	.1617	2.2
13166	Oct. 17	Slight.	Slight.	0.15	5.15	1.50	.0010	.0070	.0062	.0008	.32	.0270	.0000	.2583	2.2
13356	Nov. 21	V. slight.	V. slight.	0.40	5.60	1.65	.0040	.0100	.0086	.0014	.32	.0200	.0001	.3666	2.5
13525	Dec. 19	None.	V. slight.	0.20	5.20	1.15	.0090	.0112	.0102	.0010	.32	.0180	.0002	.2772	2.3
Av.	....	....	....	0.26	5.07	1.35	.0029	.0093	.0081	.0012	.28	.0246	.0001	.3070	2.2

Odor, faintly vegetable or none, becoming stronger on heating. —— The samples were collected from a faucet at the gate-house, and represent water flowing out of the reservoir. The reservoir is supplied with filtered water.

Microscopical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1894. Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	15	15	18	17	22	19	16	21	18	22	20
Number of sample,	11649	11755	11895	12056	12234	12407	12576	12762	12997	13166	13356	13525
PLANTS.												
Diatomaceæ,	pr.	pr.	2	85	6	0	0	0	6	2	1	1
Melosira,	0	0	0	0	0	0	0	0	6	0	0	0
Synedra,	pr.	pr.	2	76	3	0	0	0	0	2	1	1
Tabellaria,	0	0	0	9	3	0	0	0	0	0	0	0

LAWRENCE.

Microscopical Examination of Water from the Distributing Reservoir of the Lawrence Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Algæ,	0	0	0	0	0	0	212	180	560	460	0	0
Botryococcus,	0	0	0	0	0	0	210	0	0	0	0	0
Chlorococcus,	0	0	0	0	0	0	0	0	560	0	0	0
Protococcus,	0	0	0	0	0	0	2	180	0	460	0	0
Fungi, Crenothrix,	0	1	76	0	8	1	0	1	1	2	6	3
ANIMALS.												
Infusoria,	pr.	1	0	0	0	0	2	8	3	0	0	0
Mallomonas,	0	0	0	0	0	0	2	8	0	0	0	0
Monas,	0	1	0	0	0	0	0	0	0	0	0	0
Trachelomonas,	pr.	0	0	0	0	0	pr.	0	3	0	0	0
Miscellaneous, Zoöglœa,	2	1	2	0	48	3	15	0	2	12	56	80
TOTAL,	2	3	80	85	62	4	229	189	572	476	63	84

Volume of Water flowing in the Merrimack River at Lawrence on the Dates when Samples of Water were collected for Analysis.

Date.	Volume flowing in the Merrimack River in Cubic Feet per Second.		Date.	Volume flowing in the Merrimack River in Cubic Feet per Second.	
	Rate of Flow during Eleven Hours of the Day.	Rate of Flow during the Whole Twenty-four Hours.		Rate of Flow during Eleven Hours of the Day.	Rate of Flow during the Whole Twenty-four Hours.
1894.			1894 — Con.		
Jan. 17,	4,900	4,050	July 18,	3,655	2,622
Feb. 14,	5,950	5,100	Aug. 15,	2,668	2,038
March 14,	20,390	19,640	Sept. 19,	3,886	2,218
April 16,	12,830	11,920	Oct. 17,	5,625	3,589
May 16,	4,290	3,380	Nov. 21,	5,595	3,638
June 20,	3,600	2,680	Dec. 19,	6,535	4,633

LEICESTER.

WATER SUPPLY OF THE LEICESTER WATER SUPPLY DISTRICT, LEICESTER.

Chemical Examination of Water from the Wells of the Leicester Water Supply District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11920	Mar. 19	V. slight.	None.	0.10	4.60	.0000	.0018	.19	.0380	.0000	.1422	1.6	.0300
12383	June 18	None.	None.	0.10	4.65	.0002	.0010	.21	.0500	.0000	.1263	1.4	.0050
12982	Sept. 18	None.	None.	0.04	6.50	.0000	.0004	.23	.0600	.0000	.0077	2.2	.0000
13320	Nov. 16	None.	V. slight.	0.17	10.20	.0000	.0044	.24	.0570	.0001	.1755	4.7	.0220
Av.	....	....	....	0.10	6.49	.0001	.0019	.22	.0513	.0000	.1129	2.5	.0143

Odor, none. —— The samples were collected from a faucet in the village.

Microscopical Examination.

An insignificant number of organisms was found in each of these samples.

Chemical Examination of Water from Burncoat Pond and from Cedar Meadow Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
13216	Oct. 25	Decided.	Heavy, earthy.	0.30	8.15	1.85	.0148	.0608	.0178	.0430	.36	.0030	.0001	.4503	3.2
13217	Oct. 25	Distinct.	Cons., earthy.	1.40	4.50	2.15	.0082	.0368	.0290	.0078	.27	.0000	.0000	.7702	1.9

Odor, faintly vegetable; of the second sample, also mouldy. —— The first sample was collected from Burncoat Pond, at its outlet, and the second sample from Cedar Meadow Pond. The samples were collected while making an examination of possible sources of water supply for the city of Worcester.

Microscopical Examination.

No. 13216. Total number of organisms, 840, chiefly Diatomaceæ.
No. 13217. Total number of organisms, 22, chiefly Diatomaceæ.

For results of examinations of samples of water collected from Kettle Brook in Leicester, see *Worcester*.

LEOMINSTER.

WATER SUPPLY OF LEOMINSTER.

Chemical Examination of Water from Haynes Reservoir, Leominster.

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11668	Jan. 22	Slight.	Slight.	0.25	3.35	1.75	.0120	.0202	.0182	.0020	.14	.0030	.0002	.5174	0.5
11918	Mar. 19	Slight.	Cons.	0.18	2.30	1.25	.0174	.0198	.0148	.0050	.16	.0020	.0000	.3278	0.2
12280	May 23	Distinct.	Cons.	0.25	2.77	1.55	.0000	.0250	.0186	.0064	.12	.0000	.0000	.3744	0.2
12591	July 23	Decided, green.	Cons., yellow.	0.35	3.25	2.25	.0106	.0538	.0278	.0260	.16	.0040	.0001	.5683	0.2
12998	Sept. 19	Decided, green.	Cons., green.	0.30	3.35	2.10	.0006	.0514	.0234	.0280	.18	.0000	.0000	.4312	0.6
13352	Nov. 21	Distinct.	Slight.	0.35	3.10	1.85	.0204	.0378	.0256	.0122	.16	.0030	.0000	.5577	0.3
Av.	....	....	....	0.28	3.02	1.79	.0102	.0347	.0214	.0133	.15	.0020	.0001	.4628	0.3

Averages by Years.

-	1887*	-	-	0.58	3.61	2.00	.0040	.0647	-	-	.13	.0084	-	-	-
-	1888	-	-	0.36	2.80	1.42	.0023	.0352	-	-	.12	.0075	.0001	-	-
-	1889	-	-	0.27	2.35	0.94	.0010	.0426	.0254	.0172	.11	.0034	.0001	-	-
-	1890	-	-	0.21	2.86	1.66	.0003	.0500	.0210	.0290	.11	.0063	.0001	-	0.6
-	1891	-	-	0.24	2.80	1.48	.0005	.0482	.0231	.0251	.10	.0097	.0001	-	0.2
-	1893	-	-	0.32	2.98	1.72	.0050	.0462	.0244	.0218	.14	.0028	.0001	.5001	0.4
-	1894	-	-	0.28	3.02	1.79	.0102	.0347	.0214	.0133	.15	.0020	.0001	.4628	0.3

* June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable; on heating, sometimes grassy or disagreeable. —— The samples were collected from the reservoir near the gate-house, at a depth of about 1 foot beneath the surface.

LEOMINSTER.

Microscopical Examination of Water from Haynes Reservoir, Leominster.

[Number of organisms per cubic centimeter.]

	1894.					
	Jan.	Mar.	May.	July.	Sept.	Nov.
Day of examination,	24	20	25	24	20	22
Number of sample,	11668	11918	12280	12591	12998	13352
PLANTS.						
Diatomaceæ,	8	223	782	902	1,388	2,655
Asterionella,	0	19	40	580	664	348
Diatoma,	0	0	0	0	54	0
Melosira,	4	70	50	164	656	0
Navicula,	0	0	0	3	0	0
Synedra,	3	34	92	3	12	2,240
Tabellaria,	1	100	600	152	2	67
Cyanophyceæ,	0	4	360	442	784	32
Anabæna,	0	0	0	11	0	0
Aphanocapsa,	0	0	0	4	0	0
Chroöcoccus,	0	0	0	4	0	0
Clathrocystis,	0	4	360	420	0	32
Cœlosphærium,	0	0	0	3	784	0
Algæ,	7	27	75	404	98	49
Arthrodesmus,	1	0	7	0	0	1
Chlorococcus,	0	1	0	136	0	0
Closterium,	0	1	0	0	0	2
Hyalotheca,	0	0	0	0	0	10
Ophiocytium,	0	0	0	0	8	0
Pediastrum,	0	1	4	15	30	0
Polyedrium,	0	0	0	11	0	0
Protococcus,	0	0	12	50	0	0
Raphidium,	0	0	2	112	30	0
Scenedesmus,	6	24	48	48	22	36
Staurastrum,	0	0	2	32	8	0
Fungi, Crenothrix,	0	4	0	5	4	0
ANIMALS.						
Rhizopoda, Arcella,	0	0	0	0	12	0
Infusoria,	160	179	372	21	0	18
Ciliated infusorian,	0	1	0	0	0	0
Dinobryon,	0	1	0	0	0	0
Dinobryon cases,	0	138	368	0	0	4
Euglena,	3	0	0	0	0	0
Mallomonas,	0	0	0	1	0	0
Peridinium,	144	38	2	7	0	13
Tintinnidium,	1	1	2	11	0	1
Trachelomonas,	1	0	0	2	0	0
Uroglena,	11	0	0	0	0	0
Vermes,	5	2	1	3	2	3
Anurea,	0	1	0	1	2	0
Monocerca,	0	0	1	1	0	0
Polyarthra,	5	1	0	1	0	2
Rotatorian ova,	0	0	0	0	0	1
Crustacean remains,	0	0	0	.02	.01	0
Miscellaneous, Zoöglœa,	0	0	0	60	0	0
TOTAL,	180	439	1,590	1,837	2,288	2,757

LEOMINSTER.

Chemical Examination of Water from Morse Reservoir, Leominster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11667	Jan. 22	Slight.	Cons.	0.25	3.10	1.90	.0120	.0192	.0166	.0026	.14	.0030	.0002	.4819	0.2
11919	Mar. 19	V. slight.	Cons.	0.30	1.70	0.80	.0006	.0112	.0078	.0034	.12	.0000	.0000	.3831	0.2
12281	May 23	V. slight.	Slight.	0.30	2.30	0.55	.0000	.0118	.0102	.0016	.08	.0050	.0000	.3432	0.2
12590	July 23	Distinct, green.	Cons.	0.28	2.30	1.20	.0012	.0186	.0142	.0044	.16	.0000	.0001	.3965	0.2
12999	Sept. 19	Distinct.	Heavy, green.	0.50	2.95	1.25	.0000	.0266	.0158	.0108	.27	.0020	.0000	.3272	0.3
13353	Nov. 21	V. slight.	V. slight.	0.53	3.20	0.95	.0020	.0140	.0122	.0018	.25	.0000	.0000	.4992	0.3
Av.	....	....	....	0.36	2.59	1.11	.0026	.0169	.0128	.0041	.17	.0017	.0001	.4052	0.2

Averages by Years.

–	1887*	–	–	0.32	2.57	0.74	.0010	.0117	–	–	.12	.0028	–	–	–
–	1888†	–	–	0.13	1.98	0.58	.0001	.0065	–	–	.09	.0036	.0000	–	–
–	1893	–	–	0.40	2.73	1.36	.0009	.0175	.0135	.0040	.16	.0032	.0001	.5156	0.5
–	1894	–	–	0.36	2.59	1.11	.0026	.0169	.0128	.0041	.17	.0017	.0001	.4052	0.2

* June to December. † February to May.

NOTE to analyses of 1894 : Odor, generally distinctly vegetable, sometimes also grassy or unpleasant; on one occasion, none. —— The samples were collected from the reservoir.

Microscopical Examination of Water from Morse Reservoir, Leominster.

[Number of organisms per cubic centimeter.]

	1894. Jan.	Mar.	May.	July.	Sept.	Nov.
Day of examination,	24	20	25	24	20	22
Number of sample,	11667	11919	12281	12590	12999	13353
PLANTS.						
Diatomaceæ,	2	17	14	11	119	224
Asterionella,	0	1	11	0	80	0
Diatoma,	0	0	0	0	8	0
Melosira,	2	0	0	5	7	0
Navicula,	0	0	0	2	3	0
Stephanodiscus,	0	16	0	0	0	0
Synedra,	0	0	2	1	11	224
Tabellaria,	0	0	1	3	10	0

LEOMINSTER.

Microscopical Examination of Water from Morse Reservoir, Leominster — Concluded.

[Number of organisms per cubic centimeter.]

	1894.					
	Jan.	Mar.	May.	July.	Sept.	Nov.
PLANTS — Con.						
Cyanophyceæ, Clathrocystis,	7	0	0	1	0	0
Algæ,	4	pr.	142	6	3	0
Cosmarium,	1	0	1	3	0	0
Protococcus,	0	0	31	0	1	0
Raphidium,	2	0	96	0	2	0
Staurastrum,	1	pr.	1	3	0	0
Staurogenia,	0	0	13	0	0	0
Fungi, Crenothrix,	0	0	0	0	2	1
ANIMALS.						
Rhizopoda,	0	0	0	0	61	0
Arcella,	0	0	0	0	60	0
Difflugia,	0	0	0	0	1	0
Infusoria,	226	78	64	7	1	4
Ciliated infusorian,	1	0	0	0	0	0
Dinobryon,	38	2	0	0	0	0
Dinobryon cases,	10	76	60	1	0	0
Mallomonas,	0	0	4	2	0	0
Peridinium,	168	0	0	0	0	4
Tintinnidium,	0	pr.	0	4	0	0
Trachelomonas,	0	0	0	0	1	0
Uroglena,	9	0	0	0	0	0
Vermes,	5	1	1	0	0	0
Polyarthra,	5	0	1	0	0	0
Rotatorian ova,	0	1	0	0	0	0
Miscellaneous, Zoöglœa,	0	64	0	76	424	0
TOTAL,	244	160	221	101	610	229

LEXINGTON.

WATER SUPPLY OF LEXINGTON. — LEXINGTON WATER COMPANY.

In 1894 this company enlarged the capacity of its works for supplying the town by the construction of a storage reservoir on the upper portion of Vine Brook, just below Middle Street, which was completed near the end of the year. The reservoir has a capacity of about 14,250,000 gallons, and, if raised an additional foot by flash-boards, of about 16,000,000 gallons. Its area is about 5½ acres, and its water-shed, including the area of the reservoir, is about .30 of a square mile. An additional ground-water supply was also developed during the construction of the dam of this reservoir and the laying of the pipe from the dam to the pumping station, which has been availed of by turning it into this pipe.

Chemical Examination of Water from a Faucet at the Pumping Station of the Lexington Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11793	Feb. 20	V. slight.	V. slight.	1.40	10.65	4.40	.0018	.0308	.0270	.0038	.43	.1400	.0002	1.6800	4.3
12268	May 21	None.	Slight.	0.55	9.70	3.65	.0012	.0092	.0078	.0014	.79	.1360	.0001	.4134	4.3
12844	Aug. 28	Slight.	Slight.	0.08	9.15	1.40	.0000	.0040	.0032	.0008	.44	.0500	.0000	.0847	4.3
13340	Nov. 20	V. slight.	None.	1.35	14.40	5.70	.0016	.0320	.0306	.0014	.69	.2500	.0002	1.8720	5.6
Av.	....	....	....	0.85	10.98	3.79	.0012	.0190	.0172	.0018	.59	.1440	.0001	1.0125	4.6

Odor of the first two samples, faintly vegetable; of the others, none. A vegetable odor was developed in the last sample on heating.

LEXINGTON.

Microscopical Examination of Water from a Faucet at the Pumping Station of the Lexington Water Company.

[Number of organisms per cubic centimeter.]

	1894.			
	February.	May.	August.	November.
Day of examination,	22	23	30	22
Number of sample,	11793	12268	12844	13340
PLANTS.				
Diatomaceæ, Diatoma,	0	0	2	0
Fungi, Crenothrix,	0	42	2	92
Miscellaneous, Zoöglœa,	0	24	0	0
TOTAL,	0	66	4	92

WATER SUPPLY OF LINCOLN.

(See *Concord.*)

WATER SUPPLY OF LONGMEADOW.

The advice of the State Board of Health to the town of Longmeadow, relative to taking the water of Cooley Brook in Longmeadow as a source of water supply, may be found on pages 25 and 26 of this volume. The analysis of a sample of water collected from the brook is given below.

Chemical Examination of Water from Cooley Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
13182	1894. Oct. 22	None.	Slight.	0.05	5.25	1.00	.0000	.0026	.0018	.0008	.17	.0180	.0000	.0987	2.9

Odor, very faintly vegetable, disappearing on heating. —— The sample was collected from the brook.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 1; *Navicula*, 1; *Synedra*, 1. Fungi, *Crenothrix*, 88; *Molds*, 1. Total, 92.

LOWELL.

Water Supply of Lowell.

Chemical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11639	Jan. 16	V. slight.	Slight.	0.35	3.40	1.25	.0020	.0106	.0084	.0022	.19	.0050	.0001	.4033	1.4
11749	Feb. 13	V. slight.	V. slight.	0.30	3.80	1.40	.0034	.0136	.0108	.0028	.17	.0120	.0000	.4064	1.1
11879	Mar. 13	Slight.	Cons., earthy.	0.50	2.95	1.15	.0006	.0140	.0116	.0024	.12	.0120	.0000	.5584	0.5
12067	Apr. 17	Slight.	Cons.	0.40	2.60	0.85	.0010	.0128	.0104	.0024	.17	.0030	.0001	.4267	0.6
12227	May 15	Slight.	Cons.	0.50	3.10	1.25	.0056	.0140	.0106	.0034	.16	.0090	.0001	.4446	0.9
12392	June 19	Distinct.	Slight.	0.43	3.35	1.30	.0034	.0158	.0100	.0058	.15	.0030	.0002	.3965	1.1
12557	July 17	Distinct.	Slight.	0.30	5.40	1.40	.0040	.0124	.0098	.0026	.23	.0050	.0003	.3319	1.3
12767	Aug. 15	Slight, green.	Slight, green.	0.20	3.20	0.75	.0026	.0130	.0106	.0024	.20	.0050	.0001	.2464	1.1
12987	Sept. 18	Slight.	Cons.	0.18	3.60	1.45	.0056	.0128	.0110	.0018	.20	.0020	.0000	.2464	1.1
13149	Oct. 16	Slight.	Slight.	0.20	3.60	1.50	.0042	.0138	.0122	.0016	.18	.0020	.0000	.4068	1.4
13336	Nov. 20	Slight.	V. slight.	0.43	4.00	1.50	.0026	.0160	.0148	.0012	.21	.0080	.0002	.5382	1.3
13507	Dec. 18	Slight.	Slight.	0.37	3.65	1.35	.0060	.0126	.0106	.0020	.16	.0100	.0001	.3827	1.4
Av.	....	....	....	0.35	3.55	1.26	.0034	.0135	.0109	.0026	.18	.0063	.0001	.3990	1.1

Averages by Years.

-	1887*	-	-	0.44	4.29	1.16	.0021	.0158	-	-	.17	.0084	-	-	-
-	1888	-	-	0.30	3.42	0.97	.0016	.0160	.0133	.0027	.16	.0099	.0002	-	-
-	1889	-	-	0.28	2.05†	0.84†	.0018	.0149	.0126	.0023	.14	.0071	.0002	-	-
-	1890	-	-	0.30	3.57‡	1.54‡	.0014	.0128	.0104	.0024	.13	.0111	.0001	-	1.4
-	1891	-	-	0.29	3.43	1.23	.0017	.0129	.0100	.0029	.13	.0137	.0001	-	1.2
-	1892	-	-	0.39	3.61	1.36	.0021	.0141	.0113	.0028	.14	.0092	.0001	-	1.3
-	1893	-	-	0.33	3.39	1.18	.0026	.0149	.0120	.0029	.17	.0083	.0001	.4437	1.1
-	1894	-	-	0.35	3.55	1.26	.0034	.0135	.0109	.0026	.18	.0063	.0001	.3990	1.1

* June to December. † January to May. ‡ September to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable or mouldy.——The samples were collected from the river, about 1 foot beneath the surface.

For a comparison of the analyses of the river at Lowell and Lawrence for a series of years, see "Merrimack River" in the chapter on "Examination of Rivers" in a subsequent portion of this report.

LOWELL.

Microscopical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
Day of examination,	18	14	14	18	17	22	18	18	20	18	22	20
Number of sample,	11639	11749	11879	12067	12227	12392	12557	12767	12987	13149	13336	13507
PLANTS.												
Diatomaceæ,	**27**	**19**	**21**	**36**	**109**	**172**	**106**	**195**	**312**	**16**	**14**	**5**
Asterionella,	0	pr.	0	11	17	7	0	0	5	0	6	0
Diatoma,	0	0	0	0	0	0	0	0	7	2	0	0
Epithemia,	0	0	3	3	0	0	0	0	0	0	0	0
Fragilaria,	0	0	0	2	0	0	0	23	19	0	0	0
Melosira,	20	3	0	10	0	4	0	0	0	4	0	0
Navicula,	0	0	4	0	3	0	1	0	1	0	0	0
Pinnularia,	0	0	2	0	0	1	0	4	0	0	2	0
Synedra,	7	16	9	10	84	152	100	156	256	10	6	0
Tabellaria,	0	0	3	0	5	8	5	12	24	0	0	5
Algæ,	**0**	**0**	**0**	**0**	**42**	**19**	**445**	**320**	**167**	**13**	**1**	**0**
Chlorococcus,	0	0	0	0	0	0	2	0	80	5	0	0
Closterium,	0	0	0	0	0	7	0	0	0	0	1	0
Cosmarium,	0	0	0	0	0	0	0	0	8	0	0	0
Hyalotheca,	0	0	0	0	0	0	0	45	5	0	0	0
Protococcus,	0	0	0	0	37	0	440	272	37	0	0	0
Raphidium,	0	0	0	0	0	10	0	0	37	0	0	0
Scenedesmus,	0	0	0	0	5	2	3	3	0	0	0	0
Staurogenia,	0	0	0	0	0	0	0	0	0	8	0	0
Fungi,	**5**	**18**	**1**	**0**	**36**	**3**	**1**	**0**	**7**	**44**	**3**	**0**
Crenothrix,	5	0	1	0	36	3	1	0	7	44	3	0
Molds,	0	18	0	0	0	0	0	0	0	0	0	0
ANIMALS.												
Rhizopoda, Arcella,	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**5**	**0**	**0**	**0**
Infusoria,	**0**	**pr.**	**1**	**12**	**5**	**1**	**8**	**0**	**2**	**0**	**0**	**4**
Cryptomonas,	0	0	0	0	4	0	0	0	0	0	0	0
Dinobryon,	0	0	0	6	0	0	5	0	0	0	0	0
Dinobryon cases,	0	0	0	6	0	0	0	0	0	0	0	4
Monas,	0	pr.	0	0	0	0	1	0	2	0	0	0
Peridinium,	0	0	1	0	1	1	2	0	0	0	0	0
Vermes,	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**1**	**0**	**0**
Polyarthra,	0	0	0	0	0	0	2	0	0	0	0	0
Rotifer,	0	0	0	0	0	1	0	0	0	1	0	0
Miscellaneous, Zoöglœa,	**160**	**80**	**56**	**44**	**128**	**720**	**76**	**300**	**40**	**280**	**72**	**80**
TOTAL,	192	117	79	92	320	922	638	815	533	354	90	89

LOWELL.

Chemical Examination of Water from Tubular Wells in the Valley of River Meadow Brook, a Short Distance above Plain Street.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1894.												
11640	Jan. 16	None.	None.	0.00	7.50	.0000	.0008	.55	.0950	.0000	.0000	2.6	.0000
11750	Feb. 13	None.	None.	0.00	6.55	.0000	.0008	.49	.0750	.0000	.0160	2.5	.0000
11880	Mar. 13	None.	None.	0.00	6.70	.0000	.0018	.48	.0750	.0000	.0320	2.6	.0035
12068	Apr. 17	None.	None.	0.00	6.75	.0022	.0006	.56	.0600	.0000	.0320	2.6	.0040
12228	May 15	None.	None.	0.00	6.80	.0008	.0014	.48	.0580	.0000	.0374	2.3	.0100
12393	June 19	None.	None.	0.02	7.10	.0000	.0000	.54	.0500	.0000	.0423	2.6	.0085
12558	July 17	None.	None.	0.03	7.00	.0004	.0014	.57	.0400	.0001	.0177	2.5	.0140
12743	Aug. 14	None.	None.	0.04	7.40	.0000	.0018	.53	.0580	.0002	.0331	3.0	.0050
12988	Sept. 18	None.	None.	0.05	7.60	.0000	.0006	.64	.0400	.0002	.0154	2.9	.0050
13150	Oct. 16	V. slight.	V. slight.	0.04	8.10	.0000	.0018	.59	.0400	.0003	.0118	3.1	.0120
13337	Nov. 20	None.	None.	0.04	8.30	.0000	.0036	.56	.0380	.0007	.0234	3.8	.0140
13508	Dec. 18	None.	None.	0.02	8.30	.0000	.0014	.55	.0300	.0004	.0038	3.6	.0250
13540	Dec. 21	None.	V. slight.	0.00	8.00	.0004	.0034	.60	.0300	.0003	.0308	3.5	.0100
Av.*	....	....	....	0.02	7.33	.0003	.0014	.55	.0549	.0002	.0232	2.8	.0078

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

The odor in June was faint; in July and August, distinct; at other times, none.——The samples were collected from a faucet at the pumping station while pumping. These wells are locally known as the "Cook" wells.

Microscopical Examination.

A very small number of Crenothrix was found in the samples collected in May, July and October and on December 24. Small numbers of Zoöglœa were found in the September and October samples. No organisms were found in the remaining samples.

Water Supply of Ludlow.

(See *Springfield.*)

Water Supply of Lynn and Saugus.

In the latter part of 1893 the city of Lynn exercised the authority granted it by the Legislature to take the water of the Saugus River as an additional supply, and during 1894 water has been from time to time diverted from the river either directly to the city or to the existing ponds and reservoirs. The water is drawn from the river at the outlet of Howlett's Pond, and thence flows through a short canal to the canal already in use for conveying water from the Hawkes and Penny Brook sources.

The Saugus River at Howlett's Dam has a drainage area, as determined from the topographical map of the State, of 16.64 square miles, and upon this area there is estimated to be a population of 11,800, equivalent to 709 per square mile of drainage area. At the upper end of Howlett's Pond, a tributary from Wakefield joins the river. At the head of this tributary is Crystal Lake, practically all of the water of which is taken by the Wakefield Water Company for the supply of Wakefield and Stoneham. Upon the remaining 3.08 square miles of water-shed of the brook there is a population of about 3,726, equal to 1,210 per square mile. Near the head of the main stream, in Wakefield, is Lake Quannapowitt, having a water-shed of 4.35 square miles. Upon the water-shed of this lake there is a population of about 5,854 in the towns of Reading and Wakefield, equal to 1,346 per square mile.

Between the outlet of Lake Quannapowitt and Howlett's Dam the river flows much of the way through extensive meadows and swamps, which probably have an area of as much as one square mile, and in its course through this region receives two tributaries from the north, — Beaver Dam Brook and a brook flowing from Pilling's Pond. Exclusive of the water-sheds of all the tributaries mentioned, the area of water-shed tributary to the main stream between the outlet of Lake Quannapowitt and Howlett's Dam is about 4 52 square miles.

Beaver Dam Brook drains an area of 1.76 square miles above a point about a quarter of a mile north of the Newburyport branch of

the Boston & Maine Railroad. The drainage area contains the small village of Lynnfield Centre. Pilling's Pond at its outlet drains an area of 2.05 square miles, which contains very little population. It is an artificial reservoir, formed many years ago by flooding a level meadow to a depth of 4 feet. Its area is about 85 acres and its average depth about 3 feet.

With regard to the quality of the water of the Saugus River, the State Board of Health, in a communication to the Lynn Water Board (annual report for 1893, pages 25–28), expressed the opinion that the Saugus River, at the point from which the city of Lynn now takes the water, receives so much polluting matter from the towns of Reading and Wakefield as to render it an unfit source from which to take a water supply, unless the water is very thoroughly purified by filtration.

In June the water of Walden Pond was drawn off and wasted into the Saugus River, to give an opportunity to remove the soil from the bed of the pond in the vicinity of the dam. About 11 acres were cleaned, and some peaty deposits of considerable depth were covered with sand and gravel. An arm of the pond containing about 12.8 acres, where the water was shallow, was separated from the main portion by a dam across its lower end, constructed with soil removed from the bed of the pond immediately below. A pipe provided with a gate was laid under the dam. The pond remained empty at the end of the year.

In the following tables, in addition to the results of examinations of samples of water from the four ponds, as in previous years, may be found the results of examinations of samples of water collected from the Saugus River at Howlett's Dam, and just above the point where it is joined by the brook from Wakefield, and from a faucet in the city.

LYNN AND SAUGUS.

Chemical Examination of Water from Breed's Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11599	Jan. 3	Slight.	Slight.	0.90	4.90	2.05	.0020	.0352	.0286	.0066	.70	.0140	.0001	.5905	1.1
11733	Feb. 7	Distinct.	Slight.	0.50	3.80	1.30	.0102	.0212	.0188	.0024	.64	.0030	.0003	.4672	0.8
11861	Mar. 7	Slight.	Slight.	0.60	3.35	1.45	.0034	.0182	.0158	.0024	.46	.0050	.0000	.5880	0.6
12000	Apr. 5	Slight.	Slight.	0.60	3.70	1.40	.0014	.0192	.0164	.0028	.56	.0030	.0001	.5236	0.8
12160	May 7	Slight.	Cons.	0.55	3.75	1.65	.0006	.0270	.0240	.0030	.50	.0000	.0000	.6265	0.8
12326	June 6	Distinct.	Cons.	0.63	3.95	1.60	.0008	.0202	.0168	.0034	.50	.0030	.0000	.5390	0.5
12503	July 10	V. slight.	V. slight.	0.55	3.25	1.25	.0000	.0174	.0156	.0018	.62	.0000	.0000	.5428	0.8
12688	Aug. 8	Distinct, green.	Slight, green.	0.53	3.65	1.35	.0010	.0258	.0180	.0078	.58	.0000	.0000	.5020	1.3
12924	Sept. 11	Slight, green.	Slight.	0.70	3.60	1.45	.0008	.0220	.0194	.0026	.57	.0020	.0000	.4389	0.9
13108	Oct. 9	Slight.	Slight.	0.65	3.70	1.45	.0014	.0232	.0200	.0032	.54	.0000	.0000	.4446	0.9
13291	Nov. 12	V. slight.	V. slight.	0.70	3.40	1.15	.0032	.0178	.0164	.0014	.62	.0030	.0000	.4914	0.8
13464	Dec. 10	V. slight.	Slight.	0.90	4.20	1.55	.0032	.0232	.0190	.0042	.65	.0050	.0000	.5621	1.1
Av.	....	....	....	0.65	3.77	1.47	.0023	.0225	.0191	.0034	.58	.0032	.0000	.5264	0.9

Averages by Years.

-	1887*	-	-	0.51	3.70	1.32	.0006	.0217	-	-	.44	.0024	-	-	-
-	1888	-	-	0.48	3.71	1.42	.0029	.0227	-	-	.45	.0053	.0001	-	-
-	1889	-	-	0.45	3.09	1.02	.0007	.0208	.0165	.0043	.41	.0035	.0001	-	-
-	1890	-	-	0.42	3.62	1.51	.0014	.0196	.0155	.0041	.41	.0052	.0001	-	1.1
-	1891	-	-	0.35	3.35	1.37	.0009	.0156	.0131	.0025	.40	.0080	.0001	-	0.8
-	1892	-	-	0.43	3.65	1.38	.0004	.0220	.0177	.0043	.49	.0055	.0000	-	1.0
-	1893	-	-	0.65	3.61	1.41	.0039	.0214	.0181	.0033	.55	.0054	.0001	.5102	1.1
-	1894	-	-	0.65	3.77	1.47	.0023	.0225	.0191	.0034	.58	.0032	.0000	.5264	0.9

* June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable and frequently also unpleasant or grassy. —— The samples were collected from the pond near the gate-house, about 1 foot beneath the surface.

LYNN AND SAUGUS.

Microscopical Examination of Water from Breed's Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
Day of examination,	4	8	8	6	8	7	11	10	13	10	13	11
Number of sample,	11599	11733	11861	12000	12160	12326	12503	12688	12924	13108	13291	13464
PLANTS.												
Diatomaceæ,	**0**	**0**	**18**	**363**	**1,352**	**3,144**	**116**	**168**	**416**	**160**	**40**	**21**
Asterionella,	0	0	18	296	352	144	0	0	280	68	30	16
Melosira,	0	0	0	20	0	0	0	0	0	0	2	0
Tabellaria,	0	0	0	47	1,000	3,000	116	168	136	92	8	5
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**10**	**16**	**5**	**0**	**0**
Anabæna,	0	0	0	0	0	0	5	10	0	5	0	0
Tetrapedia,	0	0	0	0	0	0	0	0	16	0	0	0
Algæ,	**0**	**0**	**2**	**14**	**116**	**76**	**1**	**37**	**75**	**10**	**0**	**0**
Chlorococcus,	0	0	0	0	0	33	0	0	0	0	0	0
Protococcus,	0	0	0	12	18	29	0	22	10	0	0	0
Raphidium,	0	0	0	0	26	14	0	10	62	10	0	0
Staurastrum,	0	0	0	0	72	0	1	5	1	0	0	0
Zoöspores,	0	0	2	2	0	0	0	0	2	0	0	0
Fungi, Crenothrix,	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**3**	**0**	**1**	**0**
ANIMALS.												
Rhizopoda,	**0**	**4**	**pr.**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Actinophrys,	0	2	pr.	0	0	0	0	0	0	0	0	0
Euglypha,	0	2	0	0	1	0	0	0	0	0	0	0
Infusoria,	**13**	**46**	**15**	**379**	**527**	**37**	**65**	**20**	**3**	**73**	**21**	**1**
Chlamydomonas,	0	4	0	0	0	0	0	0	0	0	0	0
Cryptomonas,	3	0	1	0	0	0	0	0	0	0	1	0
Dinobryon,	0	28	0	244	0	23	0	0	0	0	0	0
Dinobryon cases,	0	9	3	124	520	10	60	0	0	68	0	0
Euglena,	0	0	0	0	0	2	0	0	0	0	0	0
Mallomonas,	0	0	0	8	2	1	1	0	0	2	16	1
Monas,	0	0	pr.	1	0	1	0	0	0	0	0	0
Peridinium,	10	4	11	2	4	0	3	10	3	1	1	0
Tintinnidium,	0	0	0	0	0	0	0	8	0	0	0	0
Trachelomonas,	0	1	pr.	0	1	0	1	2	0	2	3	0
Vermes,	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**5**	**0**	**0**	**1**	**0**
Anuræa,	0	0	0	1	0	0	0	1	0	0	1	0
Polyarthra,	0	0	0	0	0	0	0	2	0	0	0	0
Rotifer,	0	0	0	0	1	1	0	2	0	0	0	0
Miscellaneous, Zoöglœa,	**4**	**7**	**7**	**10**	**5**	**0**	**0**	**440**	**10**	**48**	**68**	**0**
TOTAL,	17	57	42	767	2,002	3,260	187	680	523	296	131	22

LYNN AND SAUGUS.

Chemical Examination of Water from Birch Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11598	Jan. 3	Distinct.	Slight.	0.75	4.60	1.90	.0084	.0254	.0208	.0046	.65	.0100	.0001	.4454	0.9
11732	Feb. 7	Distinct.	Slight.	0.80	4.45	1.85	.0258	.0314	.0228	.0086	.57	.0150	.0003	.6760	1.1
11860	Mar. 7	Distinct.	Slight.	0.75	4.15	2.00	.0094	.0284	.0262	.0022	.50	.0070	.0001	.6600	0.8
11999	Apr. 5	Distinct.	Cons., green.	0.58	3.75	1.45	.0024	.0338	.0242	.0096	.51	.0030	.0001	.5582	0.8
12159	May 7	Slight.	Cons.	0.48	2.55	1.20	.0008	.0258	.0216	.0042	.51	.0030	.0001	.5970	0.8
12325	June 6	Distinct, green.	Cons.	0.70	4.40	1.75	.0026	.0254	.0222	.0032	.50	.0000	.0000	.5813	0.8
12502	July 10	Distinct, green.	V. slight.	0.55	3.85	1.85	.0006	.0248	.0216	.0032	.55	.0000	.0000	.5582	1.0
12687	Aug. 8	Distinct.	Slight, green.	0.50	4.00	1.60	.0008	.0276	.0238	.0038	.56	.0000	.0000	.5505	1.1
12923	Sept. 11	Distinct, green.	Slight, brown.	0.60	4.25	1.70	.0024	.0254	.0216	.0038	.53	.0020	.0000	.4851	1.3
13107	Oct. 9	Slight.	Cons., green.	0.90	4.15	1.90	.0018	.0330	.0262	.0068	.54	.0030	.0001	.5913	0.8
13290	Nov. 12	V. slight.	V. slight.	1.30	7.45	3.20	.0044	.0386	.0368	.0018	.68	.0300	.0002	1.1700	2.1
13463	Dec. 10	V. slight.	Slight.	1.10	6.05	2.10	.0042	.0304	.0228	.0076	.76	.0180	.0001	.6853	1.7
Av.	....	....	....	0.75	4.47	1.88	.0053	.0292	.0242	.0050	.57	.0076	.0001	.6299	1.1

Averages by Years.

-	1887*	-	-	0.57	4.02	1.61	.0016	.0289	-	-	.43	.0044	-	-	-
-	1888	-	-	0.33	3.48	1.40	.0026	.0287	-	-	.45	.0082	.0001	-	-
-	1889	-	-	0.23	2.96	1.14	.0014	.0236	.0190	.0046	.41	.0048	.0001	-	-
-	1890	-	-	0.36	3.57	1.35	.0013	.0227	.0179	.0048	.42	.0088	.0001	-	1.0
-	1891	-	-	0.42	3.26	1.30	.0005	.0241	.0183	.0058	.40	.0065	.0001	-	0.7
-	1892	-	-	0.48	3.73	1.56	.0016	.0299	.0227	.0072	.47	.0092	.0001	-	1.0
-	1893	-	-	0.75	4.21	1.63	.0052	.0299	.0218	.0081	.51	.0059	.0001	.5285	1.0
-	1894	-	-	0.75	4.47	1.88	.0053	.0292	.0242	.0050	.57	.0076	.0001	.6299	1.1

* June to December.

NOTE to analyses of 1894: Odor, distinctly vegetable and frequently also unpleasant; on heating, the odor is stronger. —— The samples were collected from the pond near the gate-house, 1 foot beneath the surface.

LYNN AND SAUGUS.

Microscopical Examination of Water from Birch Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	8	8	6	8	7	11	10	13	10	13	11
Number of sample,	11598	11732	11860	11999	12159	12325	12502	12687	12923	13107	13290	13463
PLANTS.												
Diatomaceæ,	**0**	**0**	**9**	**237**	**1,150**	**1,080**	**20**	**7**	**113**	**261**	**2**	**8**
Asterionella,	0	0	8	212	324	11	0	0	27	4	0	1
Cyclotella,	0	0	0	0	2	5	0	0	0	0	0	0
Melosira,	0	0	0	0	0	0	0	0	40	17	0	0
Synedra,	0	0	1	1	64	0	0	0	2	136	1	5
Tabellaria,	0	0	0	24	760	1,064	20	7	44	104	1	2
Cyanophyceæ, Anabæna,	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**80**	**1**	**0**	**0**	**0**
Algæ,	**0**	**0**	**1**	**0**	**85**	**189**	**73**	**74**	**12**	**56**	**1**	**3**
Arthrodesmus,	0	0	0	0	0	0	2	3	3	0	0	0
Botrycoccus,	0	0	0	0	0	0	10	0	0	0	0	0
Chroöcoccus,	0	0	0	0	0	128	5	0	0	0	0	0
Closterium,	0	0	1	0	0	1	1	0	1	7	0	1
Protococcus,	0	0	0	0	25	30	45	45	0	40	0	1
Raphidium,	0	0	0	0	16	0	8	0	0	6	0	0
Staurastrum,	0	0	0	0	44	28	2	24	7	3	0	0
Zoöspores,	0	0	0	0	0	2	0	2	1	0	1	1
Fungi, Crenothrix,	**4**	**0**	**0**	**1**	**2**	**7**	**0**	**0**	**6**	**2**	**2**	**0**
ANIMALS.												
Infusoria,	**5**	**2**	**261**	**2,463**	**808**	**11**	**1,441**	**307**	**196**	**6**	**10**	**85**
Chlamydomonas,	0	0	12	0	0	0	0	0	0	0	0	0
Dinobryon,	0	0	152	720	4	0	360	0	0	0	0	0
Dinobryon cases,	0	0	76	1,680	800	0	1,080	10	184	0	0	1
Euglena,	0	0	0	0	0	1	0	0	0	0	1	0
Mallomonas,	0	0	0	0	2	3	0	0	0	1	1	0
Monas,	0	1	20	0	0	0	0	0	0	0	5	0
Peridinium,	5	pr.	1	60	1	0	0	260	1	2	2	80
Trachelomonas,	0	1	0	3	1	7	1	32	11	3	1	4
Vorticella,	0	0	0	0	0	0	0	5	0	0	0	0
Vermes,	**0**	**0**	**0**	**14**	**0**	**0**	**0**	**2**	**5**	**5**	**0**	**0**
Anuræa,	0	0	0	1	0	0	0	0	0	1	0	0
Polyarthra,	0	0	0	1	0	0	0	2	2	2	0	0
Rotatorian ova,	0	0	0	12	0	0	0	0	2	1	0	0
Rotifer,	0	0	0	0	0	0	0	0	1	1	0	0
Miscellaneous, Zoöglœa,	**0**	**10**	**24**	**0**	**8**	**0**	**0**	**108**	**88**	**108**	**0**	**0**
TOTAL,	9	12	295	2,715	2,053	1,287	1,539	578	421	438	15	96

LYNN AND SAUGUS.

Chemical Examination of Water from Walden Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11601	Jan. 3	Slight.	Slight.	1.40	5.40	2.95	.0004	.0340	.0304	.0036	.54	.0000	.0000	1.3845	0.9
11735	Feb. 7	Distinct.	Slight.	1.10	4.55	2.30	.0126	.0284	.0236	.0048	.51	.0030	.0001	1.0680	0.6
11863	Mar. 7	Slight.	Slight.	0.63	2.80	1.20	.0126	.0228	.0198	.0030	.32	.0030	.0000	0.5040	0.3
12002	Apr. 5	Distinct.	Cons., green.	0.70	3.25	1.85	.0010	.0360	.0230	.0130	.44	.0030	.0000	0.4874	0.3
12162	May 7	Slight.	Cons.	0.90	3.40	1.60	.0070	.0306	.0232	.0074	.43	.0000	.0000	0.6560	0.3
12328	June 6	Decided green.	Heavy, green.	0.90	4.30	2.45	.0000	.0560	.0240	.0320	.58	.0000	.0000	0.6306	0.3
Av.	....	....	....	0.94	3.95	2.06	.0056	.0346	.0240	.0106	.47	.0015	.0000	0.7884	0.5

Averages by Years.

-	1890	-	-	1.06	4.98	2.53	.0292	.0432	.0351	.0081	.34	.0057	.0001	-	1.1
-	1891	-	-	1.21	4.32	2.20	.0058	.0615	.0403	.0212	.34	.0091	.0001	-	0.7
-	1892	-	-	0.90	4.81	2.50	.0094	.0626	.0383	.0243	.41	.0116	.0001	-	0.6
-	1893	-	-	0.92	4.33	2.40	.0066	.0470	.0309	.0161	.44	.0047	.0001	.7954	0.7
-	1894 *	-	-	0.94	3.95	2.06	.0056	.0346	.0240	.0106	.47	.0015	.0000	.7884	0.5

* January to June.

NOTE to analyses of 1894: Odor, generally distinctly vegetable and unpleasant. —— The samples were collected from the pond near the gate-house, 1 foot beneath the surface. This reservoir was drawn off in June, and remained empty at the end of the year.

LYNN AND SAUGUS.

Microscopical Examination of Water from Walden Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1894.					
	January.	February.	March.	April.	May.	June.
Day of examination,	5	8	8	6	8	7
Number of sample,	11601	11735	11863	12002	12162	12328
PLANTS.						
Diatomaceæ,	**0**	**17**	**8**	**4,832**	**600**	**200**
Asterionella,	0	1	6	4,800	600	200
Melosira,	0	0	0	30	0	0
Synedra,	0	16	0	0	0	0
Tabellaria,	0	0	2	2	0	0
Cyanophyceæ,	**5**	**7**	**0**	**6**	**9**	**1,450**
Anabæna,	0	0	0	0	2	250
Clathrocystis,	5	7	0	6	7	1,150
Cœlosphærium,	0	0	0	0	0	50
Algæ,	**0**	**30**	**1**	**208**	**640**	**150**
Cosmarium,	0	0	0	3	1	0
Dictyosphærium,	0	0	0	0	22	0
Eudorina,	0	0	1	5	0	0
Protococcus,	0	30	0	200	41	0
Staurastrum,	0	0	0	0	560	150
Tetraspora,	0	0	0	0	16	0
Fungi, Crenothrix,	**0**	**0**	**0**	**0**	**5**	**0**
ANIMALS.						
Infusoria,	**19**	**309**	**399**	**1,386**	**28**	**100**
Cryptomonas,	2	0	18	0	0	0
Dinobryon,	0	110	1	760	0	0
Dinobryon cases,	0	32	360	400	0	0
Mallomonas,	0	0	0	2	0	0
Monas,	0	1	0	1	0	50
Peridinium,	9	30	20	220	0	0
Trachelomonas,	8	136	pr.	3	28	50
Vermes,	**1**	**1**	**0**	**3**	**1**	**0**
Monocerca,	1	1	0	0	0	0
Polyarthra,	0	0	0	2	0	0
Rotatorian ova,	0	0	0	1	0	0
Rotifer,	0	pr.	0	0	1	0
Crustacea, Daphnia,	**0**	**.05**	**0**	**0**	**0**	**0**
Miscellaneous, Zoöglœa,	**0**	**0**	**10**	**0**	**116**	**0**
TOTAL,	25	364	418	6,435	1,399	1,900

LYNN AND SAUGUS.

Chemical Examination of Water from Glen Lewis Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11600	Jan. 3	Distinct, green.	Slight.	0.80	4.65	2.00	.0004	.0528	.0264	.0264	.50	.0000	.0000	.8096	0.8
11623	Jan. 10	Slight.	Slight.	0.80	4.45	1.85	.0010	.0278	.0216	.0062	.54	.0000	.0001	.7566	0.6
11734	Feb. 7	Distinct.	Slight.	0.70	3.95	1.85	.0240	.0354	.0228	.0126	.49	.0030	.0001	.7000	0.9
11862	Mar. 7	Distinct.	Cons.	0.65	3.05	1.00	.0440	.0240	.0210	.0030	.34	.0030	.0001	.4120	0.5
12001	Apr. 5	Distinct.	Cons.	0.20	2.15	0.90	.0022	.0284	.0172	.0112	.37	.0030	.0000	.2980	0.0
12161	May 7	Distinct.	Cons., green.	0.65	3.15	1.50	.0026	.0320	.0198	.0122	.39	.0000	.0000	.5904	0.2
12327	June 6	Distinct, green.	Cons., green.	1.20	3.95	2.15	.0254	.0436	.0272	.0164	.41	.0070	.0002	.7161	0.3
12504	July 10	Decided, green.	Cons., green.	1.20	3.85	2.15	.0000	.0562	.0316	.0246	.48	.0000	.0000	.7762	0.3
12689	Aug. 8	Decided, green.	Slight, green.	1.30	4.75	2.50	.0014	.1268	.0370	.0898	.45	.0000	.0000	.7161	0.8
12925	Sept. 11	Distinct, green.	Cons.	1.30	4.00	1.80	.0060	.0720	.0480	.0240	.45	.0020	.0000	1.0087	0.8
13109	Oct. 9	Distinct.	Cons.	0.80	4.45	2.90	.0082	.0574	.0434	.0140	.44	.0000	.0002	.7676	0.5
13292	Nov. 12	V. slight.	Slight.	0.80	3.95	2.20	.0132	.0396	.0362	.0034	.47	.0070	.0001	.7878	0.5
13465	Dec. 10	V. slight.	Slight.	0.62	3.90	1.85	.0010	.0384	.0280	.0104	.44	.0030	.0001	.6868	0.3
Av.*	....	....	....	0.85	3.81	1.89	.0107	.0495	.0297	.0198	.44	.0023	.0001	.6869	0.5

Averages by Years.

–	1890	–	–	0.76	4.84	2.21	.0412	.0445	.0327	.0118	.36	.0063	.0001	–	1.0
–	1891	–	–	0.63	3.90	1.75	.0328	.0484	.0324	.0160	.34	.0124	.0002	–	0.6
–	1892	–	–	0.62	3.95	1.95	.0127	.0475	.0332	.0143	.40	.0193	.0002	–	0.6
–	1893	–	–	0.64	3.81	2.14	.0112	.0729	.0329	.0400	.42	.0040	.0002	.6048	0.6
–	1894	–	–	0.85	3.81	1.89	.0107	.0495	.0297	.0198	.44	.0023	.0001	.6869	0.5

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Note to analyses of 1894: Odor, generally decidedly vegetable and frequently also unpleasant. —— The samples were collected from the pond near the gate-house, 1 foot beneath the surface.

LYNN AND SAUGUS.

Microscopical Examination of Water from Glen Lewis Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1894.												
	Jan.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, .	5	11	8	8	6	8	7	11	10	13	10	13	11
Number of sample, .	11600	11623	11734	11862	12001	12161	12327	12504	12689	12925	13109	13292	13465
PLANTS.													
Diatomaceæ, . .	**10**	**1**	**42**	**424**	**2,354**	**4,720**	**16**	**28**	**0**	**1,404**	**180**	**29**	**0**
Asterionella, . .	4	1	42	44	2,040	3,400	16	0	0	0	7	0	0
Melosira, . . .	6	0	0	380	312	1,320	0	28	0	1,400	172	29	0
Tabellaria, . .	0	0	0	0	2	0	0	0	0	4	1	0	0
Cyanophyceæ, .	**20**	**9**	**5**	**7**	**6**	**38**	**4**	**1,536**	**2,601**	**78**	**28**	**4**	**0**
Anabæna, . . .	0	0	0	0	0	2	0	0	1,600	0	0	0	0
Chroöcoccus, . .	0	9	0	0	0	0	0	0	0	0	0	0	0
Clathrocystis, . .	20	0	5	6	6	36	2	16	1	74	14	2	0
Cœlosphærium, .	0	0	0	0	0	0	2	1,520	1,000	4	0	0	0
Microcystis, . .	0	0	0	1	0	0	0	0	0	0	14	2	0
Algæ, ...	**2**	**pr.**	**3**	**323**	**99**	**104**	**264**	**1,614**	**1**	**368**	**83**	**38**	**3**
Closterium, . .	0	0	0	3	0	1	6	0	0	168	56	36	3
Conferva, . . .	0	0	0	0	1	100	0	0	0	0	0	0	0
Cosmarium, . .	1	pr.	pr.	0	0	0	196	0	0	0	0	0	0
Eudorina, . . .	1	0	0	0	0	0	1	30	1	30	0	0	0
Pediastrum, . .	0	0	0	0	0	1	3	0	0	2	0	1	0
Protococcus, . .	0	0	3	320	96	0	10	0	0	0	23	0	0
Selenastrum, . .	0	0	0	0	0	0	0	0	0	78	4	0	0
Staurastrum, . .	0	0	0	0	2	2	48	1,584	0	90	0	1	0
Fungi, Crenothrix, .	**0**	**0**	**0**	**5**	**0**	**4**	**1**	**0**	**3**	**28**	**168**	**2**	**0**
ANIMALS.													
Infusoria, . . .	**154**	**27**	**33**	**0**	**151**	**2,086**	**42**	**2**	**1**	**80**	**178**	**27**	**6**
Chlamydomonas, .	7	0	0	0	0	0	0	0	0	0	0	0	0
Cryptomonas, . .	40	1	0	0	10	0	0	0	0	0	0	0	0
Dinobryon, . .	5	12	14	0	0	0	0	0	0	0	0	0	0
Dinobryon cases, .	10	0	1	0	124	2,080	0	0	0	0	0	0	1
Euglena, . . .	0	0	0	0	0	0	28	0	0	0	0	0	0
Glenodinium, . .	0	0	0	0	0	4	0	0	0	0	0	0	0
Monas, . . .	8	pr.	2	0	3	0	2	0	0	0	2	0	0
Peridinium, . .	80	14	16	0	14	2	0	2	0	0	0	0	1
Trachelomonas, .	4	0	0	0	0	0	1	0	1	80	176	27	4
Volvox, . . .	pr.	0	0	0	0	0	8	0	0	0	0	0	0
Volvox sporocysts, .	0	0	0	0	0	0	3	0	0	0	0	0	0
Vermes, . . .	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**1**	**6**	**0**	**0**	**1**
Monocerca, . .	0	0	0	0	0	0	0	0	1	4	0	0	0
Polyarthra, . .	0	0	0	0	0	3	0	0	0	0	0	0	0
Rotatorian ova, . .	0	0	0	0	0	0	0	0	0	2	0	0	1
Crustacea, . . .	**0**	**0**	**0**	**0**	**0**	**0**	**.04**	**.02**	**.02**	**0**	**.02**	**.03**	**0**
Cyclops, . . .	0	0	0	0	0	0	.02	.02	0	0	0	.03	0
Daphnia, . . .	0	0	0	0	0	0	.02	0	.02	0	.02	0	0
Miscellaneous, Zoöglœa,	**0**	**0**	**0**	**68**	**0**	**25**	**50**	**0**	**0**	**0**	**120**	**0**	**0**
TOTAL, . . .	186	37	83	827	2,610	6,980	377	3,180	2,607	1,964	757	100	10

LYNN AND SAUGUS.

Chemical Examination of Water from the Saugus River at Howlett's Dam, Saugus.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11794	Feb. 20	V. slight.	Slight.	1.10	6.35	2.40	.0030	.0216	.0194	.0022	.59	.0050	.0002	.9600	2.9
11865	Mar. 7	Slight.	Slight.	0.80	5.05	2.30	.0006	.0228	.0202	.0026	.55	.0150	.0002	.8104	1.8
12004	Apr. 5	Slight.	Cons., yellow.	0.60	5.80	2.20	.0008	.0196	.0162	.0034	.65	.0130	.0001	.5813	2.1
12164	May 7	Slight.	Cons.	1.80	6.80	3.05	.0018	.0324	.0298	.0026	.69	.0050	.0002	1.2972	2.3
12330	June 6	Slight.	Slight.	1.50	6.85	3.35	.0014	.0308	.0290	.0018	.58	.0030	.0000	1.0865	2.2
12506	July 10	Slight.	Slight.	0.90	9.20	2.60	.0000	.0312	.0276	.0036	1.19	.0000	.0001	.7854	4.0
12692	Aug. 8	Slight.	Cons., brown.	1.10	11.75	4.90	.0348	.0316	.0284	.0032	1.80	.0300	.0100	.5837	4.7
12929	Sept. 11	Slight.	Slight.	1.00	11.50	3.35	.0062	.0346	.0292	.0054	1.40	.0220	.0025	.5852	5.6
13113	Oct. 9	Slight.	Cons.	0.68	13.05	4.85	.0028	.0410	.0298	.0112	2.04	.0050	.0020	.6901	6.0
13295	Nov. 12	V. slight.	Cons., brown.	1.60	9.00	3.90	.0012	.0398	.0362	.0036	.76	.0030	.0001	1.7160	3.5
13467	Dec. 10	V. slight.	V. slight.	1.70	10.15	4.05	.0090	.0356	.0330	.0026	1.04	.0220	.0003	1.3860	3.8
Av.	....	....	....	1.16	8.68	3.36	.0056	.0310	.0272	.0038	1.03	.0112	.0014	0.9529	3.5

Odor, generally decidedly vegetable and frequently also unpleasant, grassy or mouldy; on heating, the odor is somewhat stronger. —— The samples were collected from the Saugus River at Howlett's Dam.

Microscopical Examination of Water from the Saugus River at Howlett's Dam, Saugus.

[Number of organisms per cubic centimeter.]

	1894.										
	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . . .	22	8	6	8	7	11	10	13	11	13	11
Number of sample, . . .	11794	11865	12004	12164	12330	12506	12692	12929	13113	13295	13467
PLANTS.											
Diatomaceæ, ...	**8**	**2**	**20**	**11**	**31**	**7**	**68**	**74**	**467**	**25**	**26**
Cyclotella, ...	1	0	1	0	1	0	1	0	400	2	0
Diatoma, ...	0	0	1	0	10	0	2	0	0	1	0
Fragilaria, ...	0	0	0	0	0	0	6	2	0	0	0
Melosira, ...	0	1	0	0	0	0	0	0	0	3	4
Meridion, ...	7	1	3	1	0	0	2	0	0	0	18
Navicula, ...	pr.	0	1	0	0	1	5	0	0	7	0
Nitzschia, ...	0	0	0	0	0	0	0	72	60	3	1
Synedra, ...	0	0	10	10	2	6	52	0	7	7	3
Tabellaria, ...	0	0	4	0	18	0	0	0	0	2	0
Cyanophyceæ, Clathrocystis, . . .	**0**	**0**	**0**	**0**	**8**	**0**	**0**	**0**	**0**	**0**	**0**
Algæ, ...	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**6**	**0**	**0**
Botrycoccus, . . .	0	0	0	0	0	10	0	0	0	0	0
Scenedesmus, . . .	0	0	0	0	0	0	0	0	6	0	0
Fungi, Crenothrix, . . .	**6**	**130**	**4**	**64**	**52**	**14**	**92**	**56**	**2**	**16**	**1**

LYNN AND SAUGUS.

Microscopical Examination of Water from the Saugus River at Howlett's Dam, Saugus — Concluded.

[Number of organisms per cubic centimeter.]

	1894.										
	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.											
Infusoria,	1	4	0	0	2	67	0	4	4	0	8
Dinobryon cases,	0	0	0	0	0	60	0	0	0	0	8
Euglena,	0	0	0	0	0	0	0	3	0	0	0
Peridinium,	1	4	0	0	0	2	0	1	1	0	0
Trachelomonas,	0	0	0	0	2	5	0	0	3	0	0
Miscellaneous, Zoöglœa,	5	0	8	4	0	6	360	64	116	0	0
TOTAL,	20	136	32	79	93	104	520	198	595	41	35

Chemical Examination of Water from the Saugus River at the Line between Saugus and Wakefield, and just above the Point where it is joined by the Wakefield Branch.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11602	Jan. 3	V. slight.	V. slight.	1.20	7.50	2.85	.0008	.0268	.0244	.0024	.69	.0020	.0000	1.1349	1.8
11731	Feb. 7	V. slight.	Slight.	0.65	4.75	1.80	.0012	.0142	.0124	.0018	.57	.0120	.0001	.6520	1.6
11866	Mar. 7	V. slight.	Cons., brown.	1.10	5.75	2.55	.0014	.0244	.0218	.0026	.55	.0030	.0000	.9720	2.3
12005	Apr. 4	Slight.	Cons., brown.	0.40	5.00	1.30	.0008	.0136	.0112	.0024	.59	.0130	.0000	.3696	1.8
12165	May 7	Slight.	Cons.	1.90	6.85	3.10	.0010	.0314	.0286	.0028	.74	.0030	.0001	1.3653	2.2
12331	June 6	V. slight.	Slight.	1.45	6.80	2.85	.0020	.0296	.0280	.0016	.50	.0070	.0000	1.1011	2.3
12507	July 10	V. slight.	Slight.	1.20	8.60	3.00	.0018	.0282	.0276	.0006	.79	.0000	.0001	.9001	3.8
12690	Aug. 8	Slight.	Slight, brown.	1.00	9.30	3.00	.0048	.0340	.0284	.0056	.24	.0030	.0000	.7007	4.4
12926	Sept. 11	Slight.	Slight, brown.	0.90	10.00	3.40	.0036	.0286	.0256	.0030	.60	.0000	.0001	.6237	5.1
13111	Oct. 9	Slight.	Slight.	0.90	8.55	3.45	.0006	.0310	.0258	.0052	.70	.0000	.0000	.7539	4.7
13293	Nov. 12	V. slight.	Slight	1.50	9.00	4.00	.0018	.0396	.0372	.0024	.75	.0000	.0000	1.7316	3.4
13468	Dec. 10	V. slight.	V. slight.	1.90	10.40	4.65	.0002	.0436	.0412	.0024	.76	.0020	.0000	1.7710	4.6
Av.	....	....	....	1.18	7.71	3.00	.0017	.0288	.0260	.0027	.62	.0038	.0000	1.0063	3.2

Odor, generally distinctly vegetable, sometimes also mouldy or unpleasant; on heating, the odor is generally stronger and more frequently mouldy. —— The samples were collected from the Saugus River, at a road crossing at the upper end of Howlett's Pond, just above the point where the river is joined by the Wakefield branch.

LYNN AND SAUGUS.

Microscopical Examination of Water from the Saugus River at the Line between Saugus and Wakefield, and just above the Point where it is joined by the Wakefield Branch.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Date of examination,	5	8	9	6	8	7	11	10	13	11	13	11
Number of sample,	11602	11731	11866	12005	12165	12331	12507	12690	12926	13111	13293	13468
PLANTS.												
Diatomaceæ,	**2**	**6**	**12**	**33**	**17**	**79**	**3**	**5**	**36**	**5**	**9**	**3**
Asterionella,	0	0	3	0	0	20	0	0	2	0	0	0
Cymbella,	0	0	0	0	0	0	0	4	1	1	0	0
Fragilaria,	0	0	0	0	5	0	0	0	20	0	0	0
Melosira,	0	0	0	9	0	0	0	0	10	0	3	0
Meridion,	0	4	7	0	0	0	0	0	0	0	1	2
Navicula,	0	0	0	1	0	0	0	0	3	2	1	0
Synedra,	2	2	1	20	5	3	1	1	0	2	4	1
Tabellaria,	0	0	1	3	7	56	2	0	0	0	0	0
Algæ,	**0**	**0**	**0**	**0**	**0**	**97**	**0**	**0**	**0**	**0**	**0**	**0**
Protococcus,	0	0	0	0	0	90	0	0	0	0	0	0
Staurastrum,	0	0	0	0	0	7	0	0	0	0	0	0
Fungi,	**0**	**0**	**80**	**20**	**140**	**32**	**3**	**52**	**136**	**357**	**4**	**0**
Crenothrix,	0	0	58	20	140	32	3	52	136	356	4	0
Molds,	0	0	22	0	0	0	0	0	0	1	0	0
ANIMALS.												
Infusoria,	**1**	**pr.**	**14**	**7**	**1**	**3**	**0**	**0**	**1**	**1**	**0**	**31**
Dinobryon,	0	0	2	3	0	0	0	0	0	0	0	27
Dinobryon cases,	0	0	12	0	0	0	0	0	1	0	0	3
Peridinium,	1	pr.	0	0	1	0	0	0	0	1	0	1
Trachelomonas,	0	pr.	0	4	0	3	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	**4**	**4**	**32**	**0**	**0**	**10**	**0**	**52**	**28**	**9**	**0**	**0**
TOTAL,	7	10	138	60	158	221	6	109	201	372	13	34

LYNN AND SAUGUS.

Chemical Examination of Water from a Faucet in Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11624	Jan. 10	None.	V. slight.	0.80	4.55	2.65	.0094	.0248	.0228	.0020	.49	.0060	.0003	.7917	0.6
11736	Feb. 7	Slight.	Slight.	0.80	4.65	2.35	.0120	.0290	.0270	.0020	.47	.0120	.0002	.8080	0.8
11864	Mar. 7	Slight.	Slight.	0.75	4.35	2.00	.0026	.0220	.0184	.0036	.51	.0100	.0000	.6424	1.1
12003	Apr. 5	None.	Slight.	0.83	4.95	1.85	.0008	.0188	.0170	.0018	.62	.0120	.0000	.6083	1.6
12163	May 7	V. slight.	Slight.	1.00	5.70	2.75	.0000	.0204	.0190	.0014	.67	.0120	.0000	.8405	1.7
12329	June 6	Slight.	Slight.	1.00	5.10	2.30	.0006	.0230	.0194	.0036	.51	.0070	.0000	.7399	1.4
12505	July 10	Slight.	Slight.	0.60	4.30	1.70	.0004	.0186	.0172	.0014	.67	.0000	.0001	.5529	1.5
12691	Aug. 8	V. slight.	Slight.	0.75	4.85	1.50	.0004	.0204	.0182	.0022	.58	.0050	.0000	.5159	1.1
12928	Sept. 11	Slight.	Slight.	0.55	4.05	2.00	.0000	.0216	.0202	.0014	.53	.0000	.0000	.4466	1.3
13110	Oct. 9	Slight.	Cons.	0.60	3.85	1.45	.0002	.0196	.0172	.0024	.55	.0000	.0000	.4241	0.9
13294	Nov. 12	V. slight.	V. slight.	0.70	4.05	1.35	.0008	.0240	.0214	.0026	.64	.0070	.0001	.5632	1.4
13466	Dec. 10	V. slight.	V. slight.	0.73	4.75	1.50	.0000	.0168	.0152	.0016	.63	.0070	.0000	.5467	1.6
Av.	......	....	....	0.76	4.60	1.95	.0023	.0216	.0194	.0022	.57	.0065	.0001	.6234	1.3

Odor, generally distinctly vegetable, sometimes also unpleasant; on heating, the odor is generally somewhat stronger. —— The samples were collected from a faucet in the city.

LYNN AND SAUGUS.

Microscopical Examination of Water from a Faucet in Lynn.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	11	8	8	6	8	7	11	10	13	11	13	11
Number of sample,	11624	11736	11864	12003	12163	12329	12505	12691	12928	13110	13294	13466
PLANTS.												
Diatomaceæ,	**23**	**33**	**67**	**163**	**44**	**142**	**148**	**1**	**47**	**11**	**56**	**16**
Asterionella,	13	29	64	148	42	2	0	0	0	0	37	11
Melosira,	0	0	0	6	0	0	0	0	0	0	10	0
Synedra,	3	0	pr.	9	0	0	0	0	2	0	2	1
Tabellaria,	7	4	3	0	2	140	148	1	45	11	7	4
Cyanophyceæ,	**0**	**0**	**1**	**0**	**0**	**22**	**0**	**10**	**0**		**0**	**0**
Clathrocystis,	0	0	1	0	0	22	0	0	0	0	0	0
Merismopedia,	0	0	0	0	0	0	0	10	0	0	0	0
Algæ,	**20**	**1**	**1**	**8**	**40**	**2**	**0**	**193**	**15**	**1**	**1**	**0**
Closterium,	0	0	0	0	0	0	0	1	6	0	1	0
Protococcus,	10	0	0	8	0	0	0	192	5	0	0	0
Sphærozosma,	0	0	0	0	40	0	0	0	0	0	0	0
Staurastrum,	10	1	1	0	0	2	0	0	4	1	0	0
Fungi, Crenothrix,	**0**	**0**	**2**	**2**	**5**	**0**	**4**	**0**	**0**	**8**	**0**	**0**
ANIMALS.												
Infusoria,	**48**	**101**	**227**	**125**	**0**	**2**	**203**	**0**	**21**	**3**	**8**	**3**
Dinobryon,	0	52	0	0	0	0	0	0	0	0	0	0
Dinobryon cases,	0	36	220	96	0	0	200	0	16	2	0	0
Mallomonas,	0	0	0	1	0	1	0	0	0	0	5	3
Peridinium,	0	1	4	28	0	0	3	0	1	0	2	0
Trachelomonas,	48	12	3	0	0	1	0	0	4	1	1	0
Miscellaneous, Zoöglœa,	**5**	**2**	**26**	**2**	**14**	**0**	**0**	**76**	**64**	**116**	**0**	**0**
TOTAL,	96	137	324	300	103	168	355	280	147	139	65	19

LYNN AND SAUGUS.

Table showing Depth of Water in Feet in the Ponds and Storage Reservoirs of the Lynn Water Works on the Dates when Samples of Water were collected for Analysis during the Year 1894.

	Breed's Pond. High Water, 21.50 Feet.	Birch Pond. High Water, *21.50 Feet.	Walden Pond. High Water, 17.00 Feet.	Glen Lewis Pond. High Water, 17.00 Feet.
Jan. 3,	11.6	7.4	16.3	10.3
Feb. 7,	13.7	9.3	15.6	9.6
March 7,	15.7	18.8	13.3	7.4
April 4,	18.0	19.7	14.5	10.6
May 7,	19.7	22.4	15.3	13.4
June 6,	21.0	22.8	13.4	15.2
July 10,	17.7	21.9	0.0	15.4
Aug. 8,	16.3	17.5	0.0	15.3
Sept. 11,	16.0	11.2	0.0	15.0
Oct. 9,	14.2	7.7	0.0	15.1
Nov. 12,	12.4	8.9	0.0	14.7
Dec. 10,	11.1	11.4	0.0	14.8

* The water in this pond is sometimes raised somewhat above ordinary high water in the latter part of the spring, in order to increase the storage.

Water Supply of Malden, Medford and Melrose.

Spot Pond, the main source of supply of these municipalities, has not been filled since April, 1891; but, owing to the more extended use of supplementary sources by the three municipalities, the amount of water drawn from the pond in 1894 was considerably less than in 1893. As a consequence of this diminished draft the surface of the pond stood 6¼ inches higher at the end of 1894 than at the beginning, notwithstanding the much smaller amount of rainfall collected than in the previous year. The total quantity of water taken from the pond during the year represented only about 40 per cent. of the total consumption of water by these places.

In the latter part of November complaint was made of the disagreeable taste and odor of the water of Spot Pond, and an examination showed the presence of large numbers of the organism *Uroglena*. A description of this organism and its effect upon the taste and odor of water may be found in the annual report of the State Board of Health for 1891, pages 645–658.

Analyses of water from the supplementary sources of supply will be found under the names of the municipalities supplied.

MALDEN, MEDFORD AND MELROSE.

Chemical Examination of Water from Spot Pond, Stoneham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11607	Jan. 3	V. slight.	Cons.	0.08	7.15	1.55	.0070	.0122	.0110	.0012	.52	.0119	.0001	.1833	2.9
11716	Feb. 5	V. slight.	Slight.	0.25	6.50	1.85	.0058	.0160	.0142	.0018	.54	.0070	.0002	.3456	2.6
11848	Mar. 5	Slight.	Cons.	0.40	6.50	1.90	.0042	.0164	.0144	.0020	.56	.0000	.0001	.4240	2.5
11994	Apr. 4	Slight.	Cons.	0.32	6.15	1.80	.0004	.0170	.0136	.0034	.54	.0130	.0001	.3488	2.3
12155	May 3	Slight.	Cons.	0.30	6.15	1.95	.0010	.0214	.0190	.0024	.60	.0090	.0000	.4840	2.2
12334	June 5	Distinct.	Slight.	0.30	5.10	1.70	.0040	.0212	.0132	.0080	.54	.0000	.0000	.4119	2.2
12518	July 9	Slight.	Slight, green.	0.18	3.50	1.00	.0014	.0186	.0150	.0036	.58	.0000	.0001	.3727	2.2
12672	Aug. 6	Distinct, green.	Slight, green.	0.20	6.25	1.60	.0000	.0198	.0180	.0018	.59	.0000	.0000	.3234	2.2
12898	Sept. 4	Distinct.	Slight.	0.23	5.95	1.95	.0010	.0178	.0162	.0016	.59	.0020	.0000	.3388	2.2
13075	Oct. 2	Decided, milky.	Heavy, brown.	0.18	5.85	1.85	.0072	.0406	.0192	.0214	.64	.0000	.0000	.3950	2.2
13261	Nov. 5	Distinct, green.	Cons., green.	0.12	5.70	1.65	.0012	.0208	.0152	.0056	.61	.0000	.0000	.2833	2.3
13365	Nov. 21	Distinct, green.	Cons., green.	0.23	5.90	1.55	.0014	.0230	.0188	.0042	.62	.0000	.0000	.3182	2.5
13386	Nov. 26	Slight.	Cons., green.	0.22	5.85	1.30	.0026	.0214	.0158	.0056	-	.0050	.0000	.3870	2.5
13387	Nov. 26	Slight.	Cons., green.	0.20	6.40	1.90	.0018	.0246	.0182	.0064	-	.0000	.0000	.3526	2.3
13435	Dec. 4	Distinct.	Cons., green.	0.08	5.75	1.40	.0008	.0282	.0214	.0068	.57	.0030	.0000	.3758	2.5
Av.*	....	....	....	0.23	5.90	1.68	.0029	.0210	.0160	.0050	.57	.0039	.0001	.3616	2.4

Averages by Years.

-	1887†	-	-	0.25	4.33	1.24	.0004	.0207	-	-	.46	.0025	-	-	-
-	1888	-	-	0.22	3.98	1.24	.0007	.0225	-	-	.44	.0054	.0001	-	-
-	1889	-	-	0.26	3.54	1.17	.0017	.0236	.0198	.0038	.44	.0053	.0002	-	-
-	1890	-	-	0.24	3.96	1.24	.0019	.0220	.0180	.0040	.42	.0069	.0001	-	1.7
-	1891	-	-	0.21	3.70	1.27	.0008	.0183	.0161	.0022	.43	.0082	.0001	-	1.4
-	1892	-	-	0.17	4.28	1.30	.0035	.0198	.0157	.0041	.50	.0081	.0001	-	1.7
-	1893	-	-	0.29	5.70	1.71	.0085	.0197	.0162	.0035	.49	.0105	.0003	.3486	2.4
-	1894	-	-	0.23	5.90	1.68	.0029	.0210	.0160	.0050	.57	.0039	.0001	.3616	2.4

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† May to December.

NOTE to analyses of 1894: Odor, generally vegetable or none; in July, faintly disagreeable; and in December, distinctly oily. On heating, the odor is generally stronger. —— The samples were collected either from a faucet in the pumping station of the Malden water works or from the pond near by.

MALDEN, MEDFORD AND MELROSE.

Microscopical Examination of Water from Spot Pond, Stoneham.

[Number of organisms per cubic centimeter.]

	1894.														
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Nov.	Nov.	Nov.	Dec.
Day of examination,	6	7	7	5	5	12	12	7	8	5	7	22	28	28	5
Number of sample, .	11607	11716	11848	11994	12155	12334	12518	12672	12898	13075	13261	13365	13386	13387	13435
PLANTS.															
Diatomaceæ, .	**0**	**3**	**8**	**43**	**126**	**64**	**27**	**5**	**31**	**100**	**82**	**105**	**0**	**0**	**0**
Asterionella, .	0	0	0	4	28	0	0	4	12	0	8	24	0	0	0
Cyclotella, .	0	1	1	2	10	52	6	0	0	8	36	56	0	0	0
Melosira, . .	0	1	6	7	9	0	18	0	17	44	37	25	0	0	0
Meridion, . .	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0
Navicula, . .	0	0	0	0	0	1	1	0	0	14	1	0	0	0	0
Synedra, . .	0	0	1	4	3	0	2	1	0	18	0	0	0	0	0
Tabellaria, .	0	1	0	26	76	3	0	0	2	16	0	0	0	0	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**38**	**0**	**12**	**10**	**0**	**10**	**0**	**0**	**0**	**0**	**0**
Anabæna, . .	0	0	0	0	38	0	12	0	0	10	0	0	0	0	0
Microcystis, .	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
Algæ, ...	**0**	**0**	**0**	**8**	**10**	**36**	**90**	**123**	**1**	**6**	**5**	**0**	**0**	**0**	**0**
Chlorococcus, .	0	0	0	0	0	8	0	4	1	2	0	0	0	0	0
Protococcus, .	0	0	0	8	10	28	82	111	0	0	5	0	0	0	0
Raphidium, .	0	0	0	0	0	0	8	8	0	4	0	0	0	0	0
Fungi, Crenothrix,	**0**	**0**	**0**	**1**	**7**	**0**	**6**	**0**	**0**	**6**	**1**	**0**	**0**	**0**	**0**
ANIMALS.															
Rhizopoda, Actinophrys, .	**0**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Infusoria, . .	**pr.**	**2**	**6**	**83**	**45**	**5**	**16**	**32**	**3**	**28**	**191**	**87**	**15**	**21**	**40**
Dinobryon, .	0	0	0	15	2	0	0	0	0	0	3	14	0	0	0
Dinobryon cases,	0	1	2	64	40	0	1	26	0	24	176	52	0	0	0
Peridinium, .	pr.	1	4	4	1	4	15	6	2	0	2	1	0	0	0
Trachelomonas,	0	pr.	0	0	0	1	0	0	1	4	0	0	0	0	0
Uroglena, . .	0	0	0	0	0	0	0	0	0	0	10	20	15	21	40
Vorticella, .	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Vermes, Anuræa,	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous, Zoöglœa, . .	**2**	**16**	**0**	**6**	**0**	**48**	**52**	**0**	**160**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL, . .	2	23	15	141	227	153	204	170	195	150	279	192	15	21	40

Table showing Heights of Water in Spot Pond on the Dates when Samples of Water were collected for Analysis in 1894.

DATE.	Distance Below High-water Mark.	DATE.	Distance Below High-water Mark.
	Feet.		Feet.
Jan. 3, ...	7.52	July 9, ...	4.00
Feb. 7, ...	7.78	Aug. 6, ...	5.08
March 5, ...	5.15	Sept. 4, ...	6.42
April 4, ...	3.79	Oct. 2, ...	7.54
May 3, ...	2.88	Nov. 5, ...	7.37
June 5, ...	2.82	Dec. 4, ...	8.00

Water Supply of Malden.

During 1894 the works for obtaining ground water at Maplewood were enlarged by putting in 26 additional wells. The new wells are each $2\frac{1}{2}$ inches in diameter and average 41 feet in depth. They are located 24 feet apart, in a line 100 feet from the westerly edge of the driveway between Eastern Avenue and the drinking fountain at the pumping station.

Chemical Examination of Water from Tubular Wells at Maplewood (Webster Park), Malden.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11608	Jan. 3	None.	None.	0.00	23.60	.0000	.0006	2.59	.3800	.0001	.0000	11.6	.0000
11717	Feb. 5	None.	V. slight.	0.00	24.50	.0000	.0012	2.70	.2000	.0000	.0096	12.4	.0000
11849	Mar. 5	None.	Slight, earthy.	0.00	27.30	.0000	.0008	2.60	.3150	.0000	.0480	13.0	.0450
11995	April 4	None.	None.	0.00	29.40	.0000	.0012	2.77	.4250	.0000	.0038	11.0	.0020
12156	May 3	None.	None.	0.00	29.30	.0000	.0002	3.00	.4100	.0000	.0440	11.5	.0000
12335	June 5	None.	None.	0.00	30.10	.0002	.0020	2.80	.3400	.0000	.0308	14.2	.0000
12519	July 9	None.	None.	0.00	30.00	.0000	.0020	2.73	.4000	.0000	.0254	13.5	.0050
12673	Aug. 6	None.	None.	0.00	30.50	.0000	.0010	2.64	.2500	.0002	.0000	14.7	.0000
12899	Sept. 4	None.	None.	0.00	32.00	.0000	.0010	2.58	.5000	.0001	.0077	13.8	.0100
13076	Oct. 2	None.	None.	0.01	27.80	.0000	.0016	2.82	.5250	.0000	.0237	13.6	.0050
13262	Nov. 5	None.	None.	0.02	25.80	.0002	.0016	2.80	.5500	.0000	.0061	13.5	.0020
13436	Dec. 4	None.	None.	0.00	28.40	.0000	.0014	2.79	.4400	.0001	.0077	15.3	.0010
Av.	....	....	....	0.00	28.23	.0000	.0012	2.74	.3946	.0000	.0172	13.2	.0058

Averages by Years.

-	1887*	-	-	0.0	17.03	.0000	.0008	2.20	.4050	-	-	-	-
-	1888	-	-	0.0	17.45	.0000	.0003	2.30	.5081	-	-	-	-
-	1889†	-	-	0.0	16.95	.0001	.0031	1.75	.5500	.0001	-	7.3	-
-	1890	-	-	0.0	18.19	.0002	.0014	2.30	.4904	.0001	-	8.0	-
-	1891	-	-	0.0	20.83	.0001	.0007	2.23	.5146	.0001	-	9.6	-
-	1892	-	-	0.0	23.00	.0000	.0005	2.36	.5129	.0000	-	11.4	-
-	1893	-	-	0.0	23.72	.0001	.0011	2.48	.4823	.0000	.0186	11.1	.0033
-	1894	-	-	0.0	28.23	.0000	.0012	2.74	.3946	.0000	.0172	13.2	.0058

* Three samples in November and December. † June and October.

NOTE to analyses of 1894: Odor, none; on heating, a distinct odor was developed in the August sample. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

Insignificant numbers of organisms were found in six of these samples, and none in the others.

MALDEN.

Chemical Examination of Water from Tubular Test Wells in the Vicinity of Maplewood, Malden.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
13404	Nov. 27	Distinct, clayey.	None.	0.05	10.90	.0000	.0018	1.17	.1500	.0000	.0984	4.7	.0190
13457	Dec. 6	Slight.	Cons., brown.	0.00	9.40	.0020	.0010	1.20	.1700	.0015	.0308	3.0	.2000

Odor of the first sample, none, of the second, faintly vegetable, becoming disagreeable on heating. —— The first sample was collected from a test well at the corner of Columbia and Garden streets, and the last from a test well near the corner of Salem Street and Broadway. The samples were collected during an investigation for an additional water supply for Malden.

Microscopical Examination.

No organisms.

Chemical Examination of Water from Tubular Test Wells South-west of Martin's Pond, North Reading.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
13077	Oct. 3	Dec'd, milky.	Slight.	0.22	8.65	.0032	.0050	.32	.0000	.0000	.1817	3.4	.0650
13331	Nov. 16	Distinct, clayey.	V. slight.	0.20	4.90	.0002	.0012	.28	.0000	.0000	.0608	1.1	.0300
13332	Nov. 17	None.	Cons., sandy.	0.05	3.30	.0000	.0006	.24	.0000	.0000	.0280	0.8	.0120

Odor of the first sample, faintly musty; of the others, none. —— The first sample was collected from a well numbered 10, about 130 feet south of Martin's Brook and 700 feet from the pond; the second from a well numbered 17 and the third from a well numbered 18, which were respectively 500 and 950 feet from the pond and 700 and 1,000 feet from the brook. The samples were collected during an investigation for an additional water supply for Malden.

Microscopical Examination.

No. 13077. Algæ, *Protococcus*, 4. Miscellaneous, *Zoöglœa*, 92. Total, 96.

Nos. 13331 and 13332. No organisms.

WATER SUPPLY OF MANCHESTER.

Chemical Examination of Water from the Well of the Manchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11665	Jan. 22	None.	V. slight.	0.00	9.90	.0000	.0000	1.82	.0800	.0000	.0055	3.6	.0000
12222	May 15	None.	V. slight, sandy.	0.00	10.80	.0000	.0000	1.93	.0850	.0000	.0039	3.5	.0070
12618	July 26	None.	V. slight.	0.00	9.50	.0000	.0006	1.76	.0500	.0000	.0169	3.2	.0040
13551	Dec. 26	None.	V. slight.	0.01	9.10	.0000	.0016	1.77	.0650	.0000	.0000	3.4	.0000
Av.	....	....	....	0.00	9.82	.0000	.0006	1.82	.0700	.0000	.0066	3.4	.0010

Odor, none. —— The samples were collected from the well.

Microscopical Examination.

Nos. 11665 and 13551. No organisms.
No. 12222. Diatomaceæ, *Synedra*, 1; *Tabellaria*, 3. Total, 4.
No. 12618. Diatomaceæ, *Tabellaria*, 1.

WATER SUPPLY OF MARBLEHEAD.

Chemical Examination of Water from the Large Collecting Well of the Marblehead Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11584	Jan. 2	Distinct, milky.	None.	0.04	15.50	.0184	.0002	3.00	.1100	.0003	.0390	8.0	.0120
11801	Feb. 22	None.	None.	0.00	12.50	.0000	.0036	2.07	.0900	.0001	.0280	6.0	.0060
12032	Apr. 11	None.	None.	0.00	7.60	.0006	.0010	1.96	.0930	.0003	.0197	5.3	.0000
12441	June 27	Slight, milky.	Slight, rusty.	0.05	14.60	.0054	.0016	1.78	.2650	.0000	.0346	6.3	.1060
12552	July 16	Distinct.	Slight, rusty.	0.20	15.00	.0068	.0008	1.51	.0350	.0000	.0285	5.4	.1100
12804	Aug. 22	Distinct.	Cons., rusty.	0.05	14.00	.0118	.0012	1.70	.0100	.0001	.0077	5.5	.0900
13123	Oct. 11	Distinct, milky.	V. slight.	0.00	13.10	.0056	.0032	1.76	.0300	.0000	.0190	6.3	.0480
13553	Dec. 26	Slight.	Slight, rusty.	0.02	15.40	.0082	.0024	3.24	.0300	.0002	.0346	8.0	.1100
Av.	....	....	....	0.02	13.46	.0071	.0018	2.13	.0829	.0001	.0264	6.4	.0603

Odor, none. —— The samples were collected either directly from the well or from a faucet at the pumping station while pumping from the well. A small amount of water from the small collecting well (No. 2) was flowing into the large collecting well at the time of collecting Nos. 11584, 12441, 12552 and 12804, and from the tubular wells numbered 42 to 47 at the time of collecting No. 13553.

MARBLEHEAD.

Microscopical Examination of Water from the Large Collecting Well of the Marblehead Water Works.

[Number of organisms per cubic centimeter.]

	1894.							
	Jan.	Feb.	April.	July.	July.	Aug.	Oct.	Dec.
Day of examination,	4	24	13	2	17	24	15	31
Number of sample,	11584	11801	12032	12441	12552	12804	13123	13553
PLANTS.								
Fungi, Crenothrix,	0	0	0	0	1,280	100	0	2
Miscellaneous, Zoöglœa,	0	0	0	64	0	0	0	0
TOTAL,	0	0	0	64	1,280	100	0	2

Chemical Examination of Water from the Small Collecting Well, Marblehead.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11802	Feb. 22	Distinct, milky.	Cons., yellow.	-*	12.60	.0118	.0030	1.35	.0100	.0000	.0960	5.9	.2900
12033	Apr. 11	Slight, milky.	Cons., fibrous.	0.55	12.50	.0132	.0042	1.43	.0000	.0000	.0885	5.3	.3900
12803	Aug. 22	Decided.	Slight, rusty.	0.10	13.50	.0180	.0026	1.40	.0000	.0000	.0154	4.7	.2000
Av.	....	....	....	–	12.87	.0143	.0033	1.39	.0033	.0000	.0666	5.3	.2933

* Too turbid with iron to determine.

Odor of No. 11802, somewhat unpleasant; of the other samples, none.—— The samples were collected from the well, which is known as Well No. 2.

Microscopical Examination.

No. 11802. Fungi, *Crenothrix*, 160.
No. 12033. Fungi, *Crenothrix*, 920.
No. 12803. Fungi, *Crenothrix*, 240.

MARBLEHEAD.

Chemical Examination of Water from Tubular Wells in the Valley of Forest River, Salem.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12440	June 27	Distinct, milky.	Cons., rusty.	0.03	18.90	.0080	.0016	3.98	.0355	.0001	.0423	6.3	.3000
12553	July 16	Slight.	Cons., rusty.	0.15	27.50	.0094	.0012	6.66	.0180	.0001	.0300	8.6	.0700

Odor, none.—— The samples were collected while pumping from the wells.

Microscopical Examination.

No. 12440. Fungi, *Crenothrix*, 232. Infusoria, *Monas*, 2. Miscellaneous, *Zoōglœa*, 134. Total, 368.
No. 12553. Fungi, *Crenothrix*, 1,200.

Chemical Examination of Water from Ware's Pond, Marblehead.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
13151	Oct. 16	Distinct.	Slight.	0.53	9.35	3.35	.0528	.0468	.0430	.0038	1.59	.0000	.0008	.7979	3.1

Odor, decidedly mouldy and unpleasant.—— The sample was collected during an investigation with reference to the quality of the ice cut from this pond.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 2; *Melosira*, 5; *Navicula*, 1; *Synedra*, 32. Algæ, *Cœlastrum*, 1; *Dictyosphærium*, 4; *Protococcus*, 40; *Selenastrum*, 4. Infusoria, *Dinobryon*, 233; *Dinobryon cases*, 64; *Trachelomonas*, 2. Vermes, *Anurea*, 1; *Monocerca*, 1; *Polyarthra*, 5; *Rotatorian ova*, 2. Total, 397.

Water Supply of Marlborough.

During the spring of 1894, from February to May inclusive, a little over 44,000,000 gallons of water were pumped from Millham Brook for the supply of the city. Of this amount 18,000,000 gallons were pumped directly into the distributing reservoir and the remainder into Lake Williams. The quantity drawn from the brook amounted to nearly a quarter of the total quantity consumed by the

MARLBOROUGH.

city during the year. A dam is now being constructed on this brook below the pumping station and below the junction with a northerly branch, to form a large storage reservoir from which water can be drawn by the present pumps.

A separate pipe system, for fire protection only, covering about 3 miles, was constructed in 1894. Connected with this system is a covered iron tank 30 feet in diameter and 35 feet in height, elevated on a trestle 75 feet in height.

Chemical Examination of Water from Lake Williams, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11929	Mar. 19	V. slight.	V. slight.	0.05	4.00	1.00	.0002	.0142	.0114	.0028	.41	.0090	.0000	.2370	1.4
12402	June 9	V. slight.	V. slight	0.12	4.00	1.15	.0002	.0128	.0120	.0008	.46	.0000	.0000	.2241	1.7
12994	Sept. 19	None.	None.	0.15	4.35	1.25	.0000	.0166	.0150	.0016	.46	.0000	.0000	.1463	1.7
13519	Dec. 19	V. slight.	V. slight.	0.04	4.45	1.45	.0000	.0180	.0158	.0022	.48	.0030	.0000	.2910	1.9
Av.	....	....	....	0.09	4.20	1.21	.0001	.0154	.0136	.0019	.45	.0030	.0000	.2246	1.7

Averages by Years.

-	1887*	-	-	0.08	4.10	0.65	.0010	.0178	-	-	.45	.0017	-	-	-
-	1888	-	-	0.05	3.99	0.91	.0005	.0205	-	-	.44	.0054	.0001	-	-
-	1889	-	-	0.04	3.92	1.03	.0007	.0220	.0182	.0038	.46	.0064	.0001	-	-
-	1890	-	-	0.03	4.41	1.13	.0007	.0206	.0165	.0041	.46	.0078	.0000	-	2.3
-	1891	-	-	0.05	4.12	1.20	.0009	.0197	.0162	.0035	.45	.0072	.0001	-	1.8
-	1892†	-	-	0.08	4.30	1.48	.0008	.0244	.0174	.0070	.46	.0115	.0003	-	1.7
-	1893	-	-	0.05	3.95	0.88	.0014	.0169	.0136	.0033	.40	.0033	.0000	.2012	1.7
-	1894	-	-	0.09	4.20	1.21	.0001	.0154	.0136	.0019	.45	.0030	.0000	.2246	1.7

* June to December. † March and April.

NOTE to analyses of 1894: Odor of the first sample, very faintly vegetable, becoming stronger and unpleasant on heating; of the second, disagreeable, becoming vegetable on heating; of the third, none, becoming mouldy on heating; and of the last, none, becoming oily on heating. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 11929, 26; No. 12402, 581; No. 12994, 19; No. 13519, 13.

MARLBOROUGH.

Chemical Examination of Water from Millham Brook, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11928	Mar. 19	V. slight.	Slight.	0.68	4.25	1.25	.0008	.0166	.0154	.0012	.31	.0150	.0001	.5822	1.4
12054	Apr. 16	Distinct.	Slight.	0.53	3.65	1.45	.0002	.0158	.0134	.0024	.35	.0220	.0001	.4891	1.1

Odor of the first sample, none, becoming vegetable on heating; of the second sample, distinctly vegetable. —— The samples were collected from a faucet at the Millham Brook pumping station.

Microscopical Examination.

No. 11928. Diatomaceæ, *Cyclotella*, 1; *Diatoma*, 1; *Meridion*, 3; *Navicula*, 1; *Odontidium*, 2; *Synedra*, 11; *Tabellaria*, 3. Fungi, *Crenothrix*, 20. Miscellaneous, *Zoöglœa*, 34. Total, 76.

No. 12054. Diatomaceæ, *Diatoma*, 3; *Epithemia*, 1; *Fragilaria*, 2; *Meridion*, 4; *Navicula*, 3; *Pinnularia*, 1; *Synedra*, 20; *Tabellaria*, 20. Algæ, *Closterium*, 1. Total, 55.

Chemical Examination of Water from Faucets in Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
12549	July 16	None.	V. slight	0.05	4.15	1.75	.0000	.0172	.0146	.0026	.48	.0050	.0000	.1925	2.2
12550	July 16	Slight.	Cons., rusty.	0.05	5.20	1.70	.0000	.0190	.0144	.0046	.48	.0050	.0000	.2125	2.1

Odor, none. —— The first sample was collected from a faucet on Maple Street and the second from a faucet on Weed Street.

Microscopical Examination.

No. 12549. Algæ, *Protococcus*, 10; *Staurastrum*, 2. Total, 12.

No. 12550. Diatomaceæ, *Tabellaria*, 13. Cyanophyceæ, *Cœlosphærium*, 1. Algæ, *Protococcus*, 10; *Staurastrum*, 2. Fungi, *Crenothrix*, 1; *Molds*, 9. Miscellaneous, *Zoöglœa*, 124. Total, 160.

MARSHFIELD.

Water Supply of Brant Rock, Marshfield. — Brant Rock Water Company.

Chemical Examination of Water from the Works of the Brant Rock Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12499	July 9	None.	None.	0.0	11.30	.0000	.0018	2.90	.0600	.0000	.0385	2.2	.0000

Odor, none. —— The sample was collected from a faucet at the pumping station.

Microscopical Examination.

No organisms.

Water Supply of Maynard.

Chemical Examination of Water from the Maynard Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11796	Feb. 21	V. slight.	V. slight.	0.04	2.45	0.40	.0006	.0068	.0054	.0014	.23	.0020	.0000	.1320	0.5
12403	June 20	V. slight.	None.	0.08	3.30	0.90	.0000	.0076	.0062	.0014	.27	.0000	.0000	.2002	1.3
13206	Oct. 24	Distinct	Cons., green.	0.03	2.05	1.00	.0006	.0164	.0130	.0034	.28	.0000	.0000	.1319	0.5
Av.	....	....	....	0.05	2.60	0.77	.0004	.0103	.0082	.0021	.26	.0007	.0000	.1547	0.8

Odor of the first and last samples, faintly vegetable; of the second, none. On heating, all the samples had a distinctly vegetable odor. —— The first two samples were collected from faucets and the last sample from the pond. The difference between the analyses of samples collected in the village and that from the pond indicates that a large amount of ground water finds its way into the pipe leading from the pond to the pumping station.

MAYNARD.

Microscopical Examination of Water from the Maynard Water Works.

[Number of organisms per cubic centimeter.]

	1894.		
	February.	June.	October.
Day of examination,	23	22	25
Number of sample,	11796	12403	13206
PLANTS.			
Diatomaceæ,	77	104	71
Asterionella,	48	34	0
Cyclotella,	0	0	9
Synedra,	26	38	56
Tabellaria,	3	32	6
Cyanophyceæ, Microcystis,	0	0	15
ANIMALS.			
Infusoria, Dinobryon cases,	2	0	18
Miscellaneous, Zoöglœa,	22	3	192
TOTAL,	101	107	296

MEDFIELD.

Chemical Examination of Water from a Spring, Medfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid		Nitrates.	Nitrites.			
	1894.												
12848	Aug. 31	None.	None.	0.00	3.80	.0002	.0026	.29	.0000	.0000	.0000	1.4	.0050

Odor, none. —— The sample was collected from a spring near Vine Brook, about a third of a mile above North Street. This spring is used as a source of water supply by a large straw factory and by a portion of the village of Medfield.

Microscopical Examination.

No organisms.

MEDFORD.

Water Supply of Medford.

As noted in the previous annual report, works were constructed early in 1894 for pumping water for the supply of the city of Medford from three small brooks flowing from a water-shed which is contiguous to that of Spot Pond on the south. On the largest of the brooks is situated a small ice pond known as Wright's Pond. The works were of a temporary character, constructed with a view to utilizing the water of these streams during times of high flow. More permanent works are in process of construction, with a view to securing a larger quantity of water from this source, and for the purpose of supplying the higher portions of the city by means of a high-service system. During 1894 the pump was run from January 24 to May 24 inclusive, and from December 20 to the end of the year, the water being discharged into the main leading from Spot Pond to the town, the surplus not used by the town going back into the pond.

Further information regarding the water supply of Medford from Spot Pond and analyses of water from the pond may be found on pages 220–222.

Chemical Examination of Water from the Wright's Pond Source, Medford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12063	Apr. 17	V. slight.	Slight.	0.40	4.35	1.45	.0004	.0126	.0104	.0022	.45	.0050	.0001	.4251	1.6
12789	Aug. 20	Distinct, green.	Slight.	0.73	6.10	2.80	.0018	.0564	.0408	.0156	.47	.0000	.0000	.6530	1.9

Odor of the first sample, none, becoming decidedly vegetable and unpleasant on heating; of the second sample, faintly vegetable, becoming stronger on heating.——The first sample was collected from a faucet at the temporary pumping station and the second from Wright's Pond.

Microscopical Examination.

No. 12063. Diatomaceæ, *Melosira*, 25; *Meridion*, 1; *Synedra*, 130. Algæ, *Zoöspores*, 20. Fungi, *Crenothrix*, 48. Infusoria, *Dinobryon*, 11; *Dinobryon cases*, 120; *Peridinium*, 1. Total, 356.

No. 12789. Diatomaceæ, *Melosira*, 2; *Pinnularia*, 1; *Synedra*, 240. Cyanophyceæ, *Clathrocystis*, 96; Algæ, *Closterium*, 6; *Pediastrum*, 2; *Staurastrum*, 2. Infusoria, *Peridinium*, 7; *Trachelomonas*, 2. Vermes, *Monocerca*, 1; *Polyarthra*, 4; *Rotifer*, 2. Total, 365.

Water Supply of Melrose.

For information regarding the water supply of Melrose from Spot Pond and for analyses of water from the pond see pages 220–222. The results of analyses of samples of water from the auxiliary ground-water supply introduced in 1894 are given in the following table. This source furnished about one-third of the water used by the town in 1894.

Chemical Examination of Water from Tubular Wells in the Valley of Spot Pond Brook, near Wyoming Avenue, used as an Additional Source of Water Supply for Melrose.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11800	Feb. 22	None.	None.	0.00	11.60	.0000	.0032	1.33	.0970	.0000	.0320	6.1	.0040
12241	May 18	Slight, clayey.	Slight.	0.10	10.50	.0024	.0006	1.09	.0700	.0000	.0351	5.9	.0060
12388	June 18	Slight, clayey.	None.	0.08	11.55	.0014	.0000	1.30	.0500	.0002	.0162	5.9	.0170
12793*	Aug. 21	Distinct, clayey.	Cons., earthy.	0.00	11.50	.0056	.0008	1.65	.0100	.0006	.0000	5.9	.0030
12852	Sept. 4	None.	None.	0.02	15.50	.0000	.0008	1.45	.1050	.0001	.0077	7.4	.0050
12907	Sept. 10	Slight, clayey.	None.	0.05	13.00	.0014	.0008	1.46	.0500	.0001	.0000	7.4	.0200
13178	Oct. 22	None.	None.	0.02	14.90	.0012	.0010	1.55	.0770	.0004	.0181	8.3	.0060
13366	Nov. 21	V. slight, white.	Slight, earthy.	0.04	16.30	.0010	.0016	1.33	.0700	.0001	.0328	8.9	.0110
13511	Dec. 18	V. slight.	V. slight.	0.05	15.30	.0010	.0034	1.36	.0960	.0002	.0770	8.4	.0080
Av.†	....	....	....	0.04	13.24	.0017	.0014	1.38	.0684	.0002	.0269	7.1	.0084

* This sample is said to have been affected by an accidental breaking of some of the wells.

† Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor of No. 12793, distinct; of No. 12907, faintly tarry; of the other samples, none.—The samples were collected from a faucet at the pumping station, with the exception of No. 12907, which was collected from a faucet on Winthrop Street.

Microscopical Examination.

No. 12388. Miscellaneous, *Zoöglœa*, 28.
No. 12793. Fungi, *Crenothrix*, 9.
No organisms were found in the remaining samples.

MENDON.

Mendon.

Chemical Examination of Water from Mendon Pond, Mendon.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11676	Jan. 24	V. slight.	V. slight.	0.05	1.95	0.60	.0010	.0100	.0086	.0014	.27	.0030	.0000	.1698	0.6
11813	Feb. 27	V. slight	Slight.	0.04	1.85	0.90	.0010	.0118	.0096	.0022	.21	.0000	.0000	.2416	0.3
11964	Mar. 29	Distinct.	Cons.	0.06	2.00	0.85	.0012	.0156	.0132	.0024	.29	.0030	.0000	.1925	0.4
Av.	....	....	....	0.05	1.93	0.78	.0011	.0125	.0105	.0020	.26	.0020	.0000	.2013	0.4

Odor of the first and third samples, none; of the second, faintly vegetable.——The samples were collected from the pond.

Microscopical Examination of Water from Mendon Pond, Mendon.

[Number of organisms per cubic centimeter.]

	1894.		
	January.	March.	March.
Day of examination,	25	1	30
Number of sample,	11676	11813	11964
PLANTS.			
Diatomaceæ,	542	80	14
Asterionella,	0	6	pr.
Synedra,	2	0	0
Tabellaria,	540	74	14
Cyanophyceæ, Oscillaria,	0	0	2
Algæ,	0	6	2
Chlorococcus,	0	0	2
Protococcus,	0	6	0
ANIMALS.			
Infusoria,	2	17	23
Dinobryon,	0	0	2
Dinobryon cases,	2	17	11
Peridinium,	0	0	10
Vermes, Polyarthra,	0	0	1
Crustacea, Daphnia,	0	0	.04
Miscellaneous, Zoöglœa,	4	0	16
TOTAL,	548	103	58

Water Supply of Methuen.

The works are owned by the town, and were completed in the latter part of 1894. The supply is derived from tubular wells in the valley of the Spicket River, near the point where it is joined by Harris Brook. The wells are each $2\frac{1}{2}$ inches in diameter, and are in two groups. One group, located west of the Miller Road and north of Harris Brook, consists of 27 wells, ranging in depth from 25 to 37 feet, and averaging $29\frac{1}{2}$ feet. The other group, located east of the Miller Road and along the southerly side of the Spicket River, consists of 18 wells, ranging in depth from 25 to $32\frac{1}{2}$ feet, and averaging $28\frac{1}{2}$ feet. The wells in the westerly group are connected with a 10-inch main 516 feet long, and those in the easterly group with a 12-inch main 390 feet long. The mains connect before reaching the pumps at the pumping station, and there is a third pipe laid to the Spicket River for drawing water from the river in case of necessity. Provision was also made for the connection in the future of a pipe from Harris Pond, a large pond about two miles up the valley of Harris Brook.

From the pumping station water is forced to a covered distributing reservoir on Foster's Hill. The reservoir is a cylindrical chamber, the inside diameter of which is 95 feet at the top and 93 feet at the bottom, and the depth inside is 21 feet. The wall is 2 feet 6 inches thick at the top and 5 feet 6 inches thick at the bottom, which is 2 feet below the finished bottom of the reservoir. It is built of field stone, laid in American cement mortar, plastered inside with a coat of Portland cement mortar. The bottom slopes downward from the circumference to the centre, and at the latter point is 6 inches lower than at the wall. It consists of 5 inches of American cement concrete, covered with a layer of Portland cement plastering 1 inch in thickness. The covering of the reservoir consists of a brick dome in the centre, surrounded by 3 concentric brick arches 8 inches in thickness, supported by brick piers connected by brick lintel arches and by the outer wall. There are 3 rows of piers, the diameter of the outer of which is 72 feet, of the middle 48 feet and of the inner 24 feet. There are 30 piers in the outer circle, 20 in the middle and 10 in the inner. The piers are 7 feet $6\frac{1}{2}$ inches apart on centres, measured along the circumference of the circle in which they are placed, and are each 16 inches square. Over the top of the reservoir is a filling of earth and loam.

METHUEN.

Water enters the reservoir at its centre near the bottom through a cast-iron main 14 inches in diameter, and is drawn out through the same pipe. Provision is made for drawing all of the water out of the reservoir, if necessary, by means of a 6-inch waste pipe, passing from the bottom of the reservoir at its centre to the surface of the ground several hundred feet below. An overflow is also provided, extending vertically from the waste pipe to high-water level, which is 20 feet above the bottom at the circumference. An iron ventilator extends from the centre of the brick dome to a short distance above the surface of the ground. The capacity of the reservoir is a little over 1,000,000 gallons. Distributing mains are of cast iron, service pipes are of wrought iron lined with cement.

Chemical Examination of Water from the Tubular Wells of the Methuen Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12935	Sept. 10	None.	Slight, clayey.	0.00	7.50	.0000	.0014	.23	.0080	.0000	.0000	2.5	.0050
13137	Oct. 13	V. slight.	Cons., clayey.	0.05	7.20	.0000	.0038	.27	.0020	.0000	.1272	3.6	.0020
13473	Dec. 8	None.	Slight, clayey.	0.00	8.60	.0006	.0046	.27	.0070	.0000	.0323	3.1	.0080
Av.	....	....	....	0.02	7.77	.0002	.0033	.26	.0057	.0000	.0532	3.1	.0050

Odor, none. —— The samples were collected at the pumping station.

Microscopical Examination.

No organisms.

METHUEN.

Chemical Examination of Water from the Covered Reservoir of the Methuen Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
12936	Sept. 10	V. slight.	V. slight.	0.00	6.80	.0008	.0000	.19	.0080	.0003	.0154	2.7	.0050
13138	Oct. 13	None.	None.	0.05	7.80	.0000	.0018	.26	.0040	.0006	.0553	3.5	.0110
13474	Dec. 8	None.	None.	0.02	7.40	.0010	.0036	.30	.0070	.0000	.0231	3.2	.0120
Av.	....	....	....	0.02	7.33	.0006	.0018	.25	.0063	.0003	.0313	3.1	.0093

Odor, none.—— The samples were collected from a faucet near the covered reservoir, and represent water flowing out of the reservoir.

Microscopical Examination.

No organisms.

Chemical Examination of Water from Hawkes Brook, Methuen.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
13496	Dec. 17	V. slight.	V. slight.	1.30*	7.45	3.05	.0002	.0312	.0282	.0030	.33	.0320	.0000	1.2820	2.6

* Bright yellow.

Odor, faintly vegetable, becoming stronger on heating. —— The sample was collected from Hawkes Brook, during an investigation for an additional water supply for Haverhill.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 2; *Meridion*, 1; *Synedra*, 8. Algæ, *Cosmarium*, 1. Fungi, *Crenothrix*, 3. Infusoria, *Dinobryon cases*, 1. Total, 16.

MIDDLEBOROUGH.

WATER SUPPLY OF MIDDLEBOROUGH FIRE DISTRICT, MIDDLEBOROUGH.

Chemical Examination of Water from the Well of the Middleborough Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12428	June 25	None.	V. slight.	0.08	5.90	.0004	.0026	.62	.0480	.0000	.0986	2.2	.0240
12805	Aug. 22	V. slight, milky.	None.	0.15	5.75	.0008	.0038	.62	.0600	.0000	.1001	2.1	.0300
12858	Sept 3	None.	None.	0.08	5.75	.0002	.0020	.66	.0380	.0000	.1155	1.8	.0100
12915	Sept. 10	None.	Slight.	0.15	6.00	.0000	.0026	.62	.0400	.0000	.0385	2.1	.0200
13097	Oct. 8	V. slight.	Slight.	0.07	6.50	.0002	.0060	.73	.0430	.0000	.0836	2.1	.0250
13273	Nov. 7	Slight, clayey.	Slight.	0.08	5.90	.0004	.0018	.76	.0550	.0002	.0770	2.9	.0200
13446	Dec. 5	None.	None.	0.01	7.00	.0002	.0024	.78	.0980	.0001	.0462	2.7	.0280
Av.*	....	....	....	0.09	6.16	.0004	.0032	.69	.0572	.0001	.0804	2.3	.0237

Averages by Years.

-	1887†	-	-	0.00	8.39	.0004	.0019	.96	.1519	-	-	-	-
-	1888	-	-	0.00	8.67	.0001	.0025	.96	.1494	.0001	-	-	-
-	1889‡	-	-	0.00	8.77	.0002	.0024	.98	.1770	.0001	-	-	-
-	1893§	-	-	0.05	6.53	.0006	.0024	.73	.0775	.0001	.0840	2.6	.0070
-	1894†	-	-	0.09	6.16	.0004	.0032	.69	.0572	.0001	.0804	2.3	.0237

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† June to December.

‡ January to May.

§ April and September.

Odor of No. 12915, faintly disagreeable, becoming distinctly mouldy on heating; of the other samples, none. On heating, the odor of No. 13097 was decidedly grassy, and of No. 13273, faintly mouldy. —— The samples were collected from a faucet at the pumping station.

MIDDLEBOROUGH.

Microscopical Examination of Water from the Well of the Middleborough Fire District.

[Number of organisms per cubic centimeter.]

	1894.						
	June.	Aug.	Sept.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	27	23	6	12	9	8	7
Number of sample, . .	12428	12805	12858	12915	13097	13273	13446
PLANTS.							
Fungi, Crenothrix, . .	28	5	88	92	80	32	38
Miscellaneous, Zoöglœa, .	86	0	0	2	108	0	0
TOTAL, ...	114	5	88	94	189	32	38

Chemical Examination of Water from Faucets in Middleborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
12806	Aug. 23	V. slight, milky.	V. slight, rusty.	0.15*	5.85	.0036	.0060	.62	.0300	.0000	.1155	1.9	.0300
12807	Aug. 23	V. slight.	Slight, rusty.	0.08†	6.10	.0018	.0042	.62	.0400	.0000	.1116	2.2	.0350

* Four days later, .08. † Four days later, .15.

Odor of the first two samples, none.—The samples were collected from faucets in the town.

Microscopical Examination.

No. 12806. Fungi, *Crenothrix*, 32. Miscellaneous, *Zoöglœa*, 108. Total, 140.
No. 12807. Fungi, *Crenothrix*, 20.

Water Supply of Middleton.

(See *Danvers*.)

MILFORD AND HOPEDALE.

Water Supply of Milford and Hopedale. — Milford Water Company.

The advice of the State Board of Health to the Milford Water Company, relative to increasing its water supply, may be found on pages 26 and 27 of this volume. Analyses of samples of water collected from the present sources, and from sources examined in connection with the investigation for an additional water supply, are given below.

Chemical Examination of Water from the Wells of the Milford Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12101	Apr. 24	None.	Slight.	0.02	3.15	.0000	.0018	.37	.0280	.0000	.0893	1.1	.0025
12847	Aug. 31.	V. slight.	V. slight.	0.05	3.50	.0000	.0022	.30	.0150	.0000	.0308	1.3	.0080

Odor of the first sample, faintly vegetable; of the second, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No. 12101. Fungi, *Crenothrix*, 20.
No. 12847. Fungi, *Crenothrix*, 24. Miscellaneous, *Zoöglœa*, 22. Total, 46.

Chemical Examination of Water from Claflin Pond and Echo Lake, Milford.

[Parts per 100,000].

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
12100	Apr. 24	V. slight.	V. slight.	0.45	2.30	1.35	.0004	.0274	.0250	.0024	.31	.0030	.0000	.5332	0.0
12144	May 2	Distinct.	Cons.	0.25	2.40	0.90	.0000	.0248	.0166	.0082	.30	.0000	.0000	.4480	0.5

Odor of the first sample, decidedly vegetable; of the second, distinctly disagreeable, becoming less strong on heating. —— The first sample was collected from Claflin Pond and the second from Echo Lake.

Microscopical Examination.

No. 12100. Diatomaceæ, *Navicula*, 1; *Synedra*, 1. Cyanophyceæ, *Anabæna*, 1. Algæ, *Batrachospermum*, 3; *Protococcus*, 30; *Raphidium*, 4; *Staurastrum*, 1. Infusoria, *Dinobryon*, 108; *Dinobryon cases*, 176; *Peridinium*, 5; *Trachelomonas*, 1. Crustacea, *Bosmina*, 1. Miscellaneous, *Zoöglœa*, 52. Total, 384.

No. 12144. Diatomaceæ, *Asterionella*, 2; *Synedra*, 148; *Tabellaria*, 1. Algæ, *Scenedesmus*, 1. Infusoria, *Ciliated infusorian*, 1; *Cryptomonas*, 25; *Glenodinium*, 132; *Monas*, 50. Miscellaneous, *Zoöglœa*, 600. Total, 960.

MILFORD AND HOPEDALE.

Chemical Examination of Water from the Charles River at Milford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
12145	1894. May. 2	Slight.	Cons.	0.75	3.20	1.65	.0018	.0200	.0178	.0022	.29	.0000	.0000	.7280	0.5

Odor, distinctly aromatic, becoming vegetable on heating. —— The sample was collected from the basin near the pumping station. This basin is formed by a dam across the river a short distance below the wells.

Microscopical Examination.

Diatomaceæ, *Cocconema*, 2; *Epithemia*, 2; *Melosira*, 5; *Meridion*, 1; *Synedra*, 72; *Tabellaria*, 2. Algæ, *Raphidium*, 4; *Scenedesmus*, 3. Fungi, *Crenothrix*, 5. Infusoria, *Peridinium*, 1. Total, 97.

Water Supply of Millis. — Millis Water Company.

The works of the Millis Water Company were purchased by the town of Millis in 1894, but the town did not take possession until Jan. 1, 1895.

Chemical Examination of Water from the Aqua Rex Spring, Millis.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
12826	1894. Aug. 27	Slight.	Slight, green.	0.07	7.00	.0016	.0036	.42	.1250	.0001	.0000	2.1	.0050

Odor, none. —— The sample was collected from the spring.

Microscopical Examination.

Diatomaceæ, *Navicula*, 1. Infusoria, *Chlamydomonas*, 180. Total, 181.

MILTON.

Water Supply of Milton. — Milton Water Company.

The water supplied by this company to the town is purchased from the Hyde Park Water Company. Analyses of the water may be found on pages 182–184.

The reply of the State Board of Health to an application of the Milton Water Company, relative to taking water from the ground in the vicinity of Pine Tree Brook in Milton, may be found on pages 27–29 of this volume.

Analyses of samples of water collected in connection with the investigation of the proposed source of supply are given below and on page 225 of the annual report of the Board for 1893.

The replies of the State Board of Health to the school committee of Hyde Park and to the Hyde Park Water Company, relative to the water supply of Hyde Park and Milton, may be found on pages 21–24 of this volume.

Chemical Examination of Water from Tubular Test Wells in the Valley of Pine Tree Brook, Milton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12098	April 21	None.	V. slight, sandy.	0.0	4.30	.0012	.0010	.48	.1100	.0000	.0237	1.7	.0020
12099	April 21	None.	Slight, sandy.	0.0	4.50	.0006	.0008	.51	.1100	.0000	.0118	1.7	.0050

Odor of the first sample, none; of the second, distinct. —— The first sample was collected from a tubular well near Pine Tree Brook on the easterly side of Harland Street, and about 700 feet south of Canton Avenue, Milton; the second sample was collected from a test well on the westerly side of Pine Tree Brook, in Safford's Meadow, on the easterly side of Harland Street.

Microscopical Examination.

No organisms.

Water Supply of Monson.

The advice of the State Board of Health to the town of Monson, relative to taking a public water supply from the water-shed of Conant Brook in Monson, may be found on pages 29 and 30 of this volume. Analyses of samples of water from Conant and Ingalls brooks and from a test well near their junction are given below.

Chemical Examination of Water from Conant and Ingalls Brooks, Monson.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11868	Mar. 8	Slight.	Slight.	0.35	2.40	0.95	.0006	.0108	.0090	.0018	.12	.0030	.0000	.4184	0.2
11914	Mar 17	V. slight.	Slight.	0.25	2.45	0.95	.0004	.0100	.0050	.0050	.11	.0030	.0000	.3081	0.3
11915	Mar. 17	V. slight.	Cons., earthy.	0.15	2.25	0.60	.0000	.0088	.0054	.0034	.12	.0070	.0000	.2315	0.6

Odor of the first two samples, distinctly vegetable; of the last, none. —— The first sample was collected from Conant Brook, just below its junction with Ingalls Brook; the second and third from the north and south branches of Ingalls Brook respectively, just above their junction.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: No. 11868, 3; No. 11914, 26; No 11915, 7.

Chemical Examination of Water from a Test Well near the Junction of Conant and Ingalls Brooks, Monson.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11869	March 8	None.	Cons., sandy.	0.00	3.05	.0000	.0000	.10	.0000	.0000	.0216	0.5	.0270

Odor, none. —— The sample was collected from a $2\frac{1}{2}$-inch test well, 500 feet above the junction of Conant and Ingalls brooks.

Microscopical Examination.

Fungi, *Crenothrix*, 4.

MONTAGUE.

Water Supply of Turner's Falls Fire District. — Montague.

Chemical Examination of Water from Lake Pleasant, Montague.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11610	Jan. 8	V. slight.	Slight, fibrous.	0.10	2.05	0.60	.0030	.0104	.0076	.0028	.12	.0050	.0000	.0858	0.5
11719	Feb. 6	Slight.	Slight.	0.05	1.95	0.65	.0028	.0126	.0098	.0028	.11	.0030	.0000	.1600	0.3
11847	Mar. 6	V. slight.	V. slight.	0.05	1.85	0.50	.0052	.0092	.0080	.0012	.09	.0050	.0000	.1560	0.3
11997	Apr. 4	V. slight.	V. slight.	0.03	2.20	0.70	.0064	.0102	.0072	.0030	.10	.0030	.0001	.0885	0.3
12166	May 7	V. slight.	V. slight.	0.03	2.15	0.95	.0000	.0088	.0070	.0018	.12	.0030	.0000	.1279	0.3
12307	June 4	V. slight.	V. slight.	0.02	2.25	0.95	.0004	.0098	.0086	.0012	.13	.0030	.0000	.0847	0.3
12496	July 9	Slight.	Slight.	0.02	2.30	0.65	.0000	.0126	.0084	.0042	.13	.0000	.0000	.0986	0.8
12678	Aug. 7	V. slight.	Slight, fibrous.	0.02	2.25	0.75	.0006	.0090	.0068	.0022	.10	.0000	.0001	.0770	0.5
12909	Sept. 10	V. slight.	V. slight.	0.01	2.15	0.35	.0000	.0072	.0060	.0012	.11	.0020	.0000	.0770	0.5
13070	Oct. 2	V. slight.	V. slight.	0.02	2.35	0.85	.0000	.0058	.0046	.0012	.14	.0000	.0000	.1185	0.3
13258	Nov. 5	Slight.	Slight.	0.06	2.05	0.40	.0018	.0100	.0080	.0020	.14	.0030	.0001	.1116	0.5
13433	Dec. 4	Slight.	Slight.	0.03	2.05	0.75	.0058	.0102	.0086	.0016	.11	.0030	.0000	.1001	0.5
Av.	....	....	....	0.04	2.13	0.68	.0022	.0097	.0076	.0021	.12	.0025	.0000	.1071	0.4

Averages by Years.

–	1887*	–	–	0.03	2.74	0.81	.0018	.0116	–	–	.10	.0007	–	–	–
–	1888	–	–	0.00	2.33	0.49	.0027	.0071	–	–	.09	.0085	.0000	–	–
–	1889†	–	–	0.01	2.19	0.40	.0008	.0063	.0052	.0011	.09	.0088	.0000	–	–
–	1893	–	–	0.04	2.28	0.68	.0023	.0115	.0083	.0032	.12	.0045	.0000	.1137	0.6
–	1894	–	–	0.04	2.13	0.68	.0022	.0097	.0076	.0021	.12	.0025	.0000	.1071	0.4

* June to December. † January to June.

Note to analyses of 1894: Odor, generally vegetable or unpleasant, sometimes none, generally becoming somewhat stronger on heating. —— The samples were collected from faucets in the town.

MONTAGUE.

Microscopical Examination of Water from Lake Pleasant, Montague.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	–	7	7	5	8	6	10	8	12	3	7	6
Number of sample,	11610	11719	11847	11997	12166	12307	12496	12678	12909	13070	13258	13433
PLANTS.												
Diatomaceæ,	–	**1**	**7**	**80**	**166**	**334**	**5**	**4**	**2**	**4**	**5**	**17**
Cyclotella,	–	1	pr.	2	2	0	0	0	2	0	pr.	2
Fragilaria,	–	0	0	0	26	0	0	0	0	0	0	0
Melosira,	–	0	7	77	136	13	3	4	0	0	1	15
Synedra,	–	0	0	1	2	320	2	0	0	2	2	0
Tabellaria,	–	0	0	0	0	1	pr.	0	pr.	2	2	0
Cyanophyceæ, Anabæna spores,	–	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**11**	**0**	**0**
Algæ,	–	**44**	**0**	**12**	**0**	**68**	**0**	**0**	**47**	**0**	**0**	**7**
Protococcus,	–	35	pr.	12	0	68	0	0	43	0	0	0
Raphidium,	–	9	0	0	0	0	0	0	4	0	0	1
Tetraspora,	–	0	0	0	0	0	0	0	0	0	0	6
ANIMALS.												
Infusoria,	–	**14**	**2**	**10**	**5**	**0**	**0**	**0**	pr.	**0**	**0**	**0**
Dinobryon cases,	–	8	1	1	5	0	0	0	0	0	0	0
Peridinium,	–	6	1	9	0	0	0	0	pr.	0	0	0
Miscellaneous, Zoöglœa,	–	**0**	**0**	**0**	**0**	**140**	**100**	**0**	**0**	**2**	**9**	**0**
TOTAL,	–	59	9	102	171	542	105	4	49	17	14	24

WATER SUPPLY OF NAHANT.

(See *Swampscott.*)

WATER SUPPLY OF NANTUCKET. — WANNACOMET WATER COMPANY.

By reference to the table of averages by years on the following page, great fluctuations in the amount of albuminoid ammonia in the water in different years will be noticed. The larger amounts have been due to the presence in the water of abundant growths of the organism *Anabæna*, which is sometimes present in great numbers from midsummer until October. During 1894 the water remained of satisfactory quality throughout the year, and in the microscopical examinations of samples collected for analysis no *Anabæna* were found.

NANTUCKET.

Chemical Examination of Water from Wannacomet Pond, Nantucket.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
12377	June 13	V. slight.	Cons.	0.05	6.80	1.35	.0016	.0130	.0122	.0008	2.25	.0000	.0000	.1240	2.1
12500	July 9	Slight, green.	Slight.	0.08	7.15	2.00	.0000	.0184	.0140	.0044	2.42	.0000	.0000	.1771	1.4
12623	July 28	Distinct.	Slight, yellow.	0.04	6.65	1.65	.0020	.0132	.0112	.0020	2.38	.0000	.0000	.1463	1.3
12680	Aug. 7	Slight.	Slight, brown.	0.05	6.60	1.80	.0024	.0154	.0126	.0028	2.35	.0000	.0001	.1427	1.7
12900	Sept. 5	Slight.	Slight, rusty.	0.08	7.50	2.10	.0010	.0112	.0098	.0014	2.18	.0000	.0000	.1001	1.6
13085	Oct. 3	Slight.	Slight.	0.08	6.95	1.60	.0018	.0122	.0098	.0024	2.22	.0000	.0000	.1343	1.3
13271	Nov. 5	V. slight.	Slight.	0.03	6.25	1.40	.0016	.0108	.0078	.0030	2.50	.0000	.0000	.1039	1.8
13451	Dec. 5	V. slight.	V. slight.	0.00	6.20	1.50	.0008	.0136	.0108	0028	2.22	.0000	.0000	.0924	1.6
Av.*	....	....	....	0.05	6.74	1.65	.0015	.0131	.0108	.0023	2.30	.0000	.0000	.1227	1.6

Averages by Years.

–	1887†	–	–	0.08	6.72	1.20	.0002	.0175	–	–	2.20	.0020	–	–	–
–	1888‡	–	–	0.05	5.98	0.98	.0002	.0153	–	–	2.11	.0048	.0002	–	–
–	1889§	–	–	0.10	–	–	.0031	.0416	.0269	.0147	1.99	.0035	.0001	–	–
–	1890‖	–	–	0.00	–	–	.0006	.0188	.0127	.0061	1.95	.0025	.0000	–	–
–	1891¶	–	–	0.22	7.54	2.33	.0112	.0588	.0317	.0271	1.86	.0076	.0001	–	1.4
–	1892**	–	–	0.03	6.84	1.68	.0004	.0136	.0111	.0025	2.22	.0033	.0000	–	1.6
–	1893¶	–	–	0.22	7.00	2.02	.0013	.0469	.0208	.0261	2.08	.0025	.0000	.2167	1.6
–	1894††	–	–	0.05	6.74	1.65	.0015	.0131	.0108	.0023	2.30	.0000	.0000	.1227	1.6

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† July to November. ‡ February to May. § September to November.

‖ March and April. ¶ August to December. ** May to October.

†† June to December.

NOTE to analyses of 1894: Odor, generally vegetable or disagreeable, sometimes none. —— The samples were collected from the pond.

NANTUCKET.

Microscopical Examination of Water from Wannacomet Pond, Nantucket.

[Number of organisms per cubic centimeter.]

	1894.							
	June.	July.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	11	31	9	8	5	8	7
Number of sample,	12377	12500	12623	12680	12900	13085	13271	13451
PLANTS.								
Diatomaceæ,	**1**	**0**	**0**	**59**	**2**	**4**	**34**	**5**
Cyclotella,	1	0	0	3	0	0	0	0
Synedra,	0	0	0	56	2	4	34	5
Algæ,	**0**	**0**	**80**	**4**	**0**	**0**	**0**	**10**
Chlorococcus,	0	0	80	4	0	0	0	0
Protococcus,	0	0	0	0	0	0	0	10
ANIMALS.								
Infusoria,	**561**	**255**	**200**	**105**	**2**	**1**	**152**	**109**
Ceratium,	0	3	0	1	1	0	0	0
Dinobryon,	0	2	0	2	0	0	7	5
Dinobryon cases,	560	250	200	100	0	0	144	104
Peridinium,	0	0	0	2	0	1	1	0
Tintinnidium,	1	0	0	0	0	0	0	0
Vorticella,	0	0	0	0	1	0	0	0
Vermes,	**2**	**pr.**	**0**	**0**	**3**	**2**	**pr.**	**2**
Anurea,	2	0	0	0	0	0	pr.	1
Polyarthra,	0	0	0	0	2	0	pr.	0
Rotifer,	0	pr.	0	0	1	2	0	1
Miscellaneous,	**0**	**38**	**16**	**84**	**0**	**24**	**0**	**0**
Acarina,	0	.03	0	0	0	.02	.01	0
Zoöglœa,	0	38	16	84	0	24	0	0
TOTAL,	564	293	296	248	7	31	186	126

NATICK.

WATER SUPPLY OF NATICK.

Chemical Examination of Water from Dug Pond, Natick.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11579	Jan. 1	Slight.	Cons.	0.10	5.15	1.05	.0070	.0152	.0138	.0014	.76	.0170	.0000	.2168	2.3
11698	Feb. 1	V. slight.	Slight, white.	0.02	5.25	1.55	.0156	.0136	.0114	.0022	.75	.0150	.0003	.1999	2.1
11833	Mar. 1	V. slight.	Slight, white.	0.08	5.70	1.55	.0058	.0118	.0090	.0028	.81	.0370	.0001	.2400	2.6
11970	Apr. 2	Slight.	Slight.	0.18	5.55	1.10	.0026	.0124	.0106	.0018	.81	.0300	.0002	.1910	2.2
12139	May 1	Slight.	Cons., white.	0.08	5.65	2.15	.0006	.0156	.0128	.0028	.82	.0470	.0004	.2240	2.2
12466	July 2	Distinct.	Slight.	0.10	6.55	2.60	.0010	.0184	.0160	.0024	.77	.0230	.0001	.2156	2.5
12883	Sept. 4	Slight.	Slight.	0.10	6.00	1.70	.0012	.0206	.0178	.0028	.83	.0020	.0000	.1848	2.2
13275	Nov. 5	Distinct.	Slight.	0.10	5.25	1.50	.0142	.0164	.0144	.0020	.84	.0030	.0000	.2271	2.3
Av.	....	....	....	0.10	5.64	1.65	.0060	.0155	.0132	.0023	.80	.0218	.0001	.2124	2.3

Averages by Years.

–	1887*	–	–	0.14	5.25	1.21	.0039	.0215	–	–	.70	.0050	–	–	–
–	1888	–	–	0.13	5.24	1.09	.0070	.0228	–	–	.66	.0197	.0003	–	–
–	1889	–	–	0.16	5.51	1.22	.0044	.0242	.0196	.0046	.71	.0289	.0004	–	–
–	1890	–	–	0.14	5.85	1.36	.0027	.0199	.0166	.0033	.72	.0227	.0002	–	2.7
–	1891	–	–	0.09	5.71	1.45	.0085	.0207	.0167	.0040	.69	.0326	.0003	–	2.4
–	1892	–	–	0.06	5.38	1.24	.0068	.0173	.0135	.0038	.72	.0323	.0001	–	2.4
–	1893	–	–	0.08	5.28	1.39	.0062	.0192	.0158	.0034	.71	.0193	.0003	.2345	2.1
–	1894	–	–	0.10	5.64	1.65	.0060	.0155	.0132	.0023	.80	.0218	.0001	.2124	2.3

* June to December.

NOTE to analyses of 1894: Odor, generally vegetable, sometimes also vegetable or disagreeable. —— The samples were collected from a faucet at the pumping station.

NATICK.

Microscopical Examination of Water from Dug Pond, Natick.

[Number of organisms per cubic centimeter.]

	1894.							
	Jan.	Feb.	Mar.	Apr	May.	July.	Sept.	Nov.
Day of examination,	2	2	3	3	3	3	6	8
Number of sample,	11579	11698	11833	11970	12139	12466	12883	13275
PLANTS.								
Diatomaceæ,	138	29	28	376	955	67	112	491
Asterionella,	8	0	2	6	19	4	0	13
Cyclotella,	82	14	13	54	100	13	92	12
Melosira,	18	14	12	280	640	27	19	464
Synedra,	20	1	1	6	120	15	1	1
Tabellaria,	10	0	0	30	76	8	0	1
Cyanophyceæ, Microcystis,	0	0	0	0	0	56	0	0
Algæ,	2	0	pr.	0	42	214	0	12
Chlorococcus,	0	0	0	0	0	212	0	0
Protococcus,	2	0	0	0	33	0	0	8
Scenedesmus,	0	0	pr.	0	1	2	0	4
Staurogenia,	0	0	0	0	8	0	0	0
Fungi, Crenothrix,	pr.	0	pr.	.1	0	0	0	3
ANIMALS.								
Rhizopoda, Euglypha,	0	0	0	0	1	0	0	0
Infusoria,	1	0	1	pr.	5	0	3	8
Dinobryon cases,	1	0	0	0	5	0	0	7
Peridinium,	pr.	0	0	0	0	0	2	1
Trachelomonas,	0	0	1	pr.	0	0	1	0
Crustacean remains,	0	0	0	.04	.01	0	0	0
Miscellaneous, Zoöglœa,	0	1	0	16	56	28	60	0
TOTAL,	141	30	29	393	1,059	365	175	514

Table showing Heights of Water in Dug Pond on the First of Each Month in 1894.

NOTE. — High-water mark is 13.0 feet.

1894.	Height of Water.	1894.	Height of Water.
	Feet.		Feet.
Jan. 1,	9.33	July 1,	11.17
Feb. 1,	10.08	Aug. 1,	9.75
March 1,	11.46	Sept. 1,	8.25
April 1,	13.12	Oct. 1,	7.46
May 1,	13.17	Nov. 1,	7.17
June 1,	12.33	Dec. 1,	8.67

NEEDHAM.

WATER SUPPLY OF NEEDHAM.

Chemical Examination of Water from the Well of the Needham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11948	Mar. 27	None.	None.	0.00	5.65	.0034	.0008	.77	.1950	.0000	.0154	1.8	.0000
12609	July 25	None.	None.	0.02	5.10	.0000	.0000	.60	.1100	.0000	.0000	1.4	.0030
13380	Nov. 26	None.	None.	0.02	4.80	.0006	.0008	.60	.1050	.0000	.0287	1.8	.0030
Av.	....	....	....	0.01	5.18	.0013	.0005	.66	.1367	.0000	.0147	1.7	.0020

Averages by Years.

-	1891*	-	-	0.00	6.10	.0022	.0022	.72	.1500	.0000	-	1.7	-
-	1892†	-	-	0.00	6.12	.0000	.0001	.65	.1400	.0000	-	2.1	.0072
-	1893	-	-	0.00	5.28	.0000	.0007	.63	.1230	.0000	.0522	1.9	.0000
-	1894	-	-	0.01	5.18	.0013	.0005	.66	.1367	.0000	.0147	1.7	.0020

* November. † July and August.

NOTE to analyses of 1894: Odor, of the second sample, faintly vegetable, disappearing on heating; of the other samples, none.—— The samples were collected from faucets in the town.

Microscopical Examination.

No organisms.

WATER SUPPLY OF NEW BEDFORD.

The advice of the State Board of Health to the city of New Bedford relative to taking an additional water supply from the great ponds in Lakeville may be found on pages 30–34 of this volume. Analyses of samples of water from Little Quittacas, Great Quittacas and Long ponds are given on pages 252–256. For analyses of samples of water from Assawompsett and Elder's ponds, which are now used as sources of water supply by Taunton, see Taunton.

NEW BEDFORD.

Chemical Examination of Water from the Conduit of the New Bedford Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11675	Jan. 24	V. slight.	V. slight.	1.45	5.85	2.50	.0012	.0152	.0144	.0008	.62	.0070	.0000	1.2877	1.4
11806	Feb. 26	V. slight.	V. slight.	1.40	5.30	2.25	.0000	.0196	.0178	.0018	.47	.0050	.0000	1.1960	1.3
11955	Mar. 27	V. slight.	Cons.	1.00	4.05	1.45	.0016	.0158	.0146	.0012	.45	.0100	.0000	.8200	0.9
12088	Apr. 23	Slight.	Cons., rusty.	1.50	4.25	2.00	.0012	.0160	.0128	.0032	.49	.0120	.0000	.9930	0.8
12265	May 21	V. slight.	Cons., brown.	1.40	4.30	2.25	.0008	.0184	.0160	.0024	.48	.0000	.0000	.9360	0.9
12448	June 28	V. slight.	Slight.	1.70	5.05	2.65	.0002	.0202	.0186	.0016	.49	.0030	.0000	1.2081	0.9
12598	July 24	None.	Cons., brown.	1.40	4.80	2.65	.0000	.0230	.0218	.0012	.52	.0040	.0000	1.1073	0.9
12784	Aug. 20	V. slight.	Slight.	0.85	3.95	1.50	.0000	.0194	.0174	.0020	.48	.0000	.0001	.4774	0.8
13031	Sept. 25	V. slight.	Slight.	0.50	3.45	1.45	.0000	.0160	.0152	.0008	.50	.0060	.0000	.4427	0.5
13187	Oct. 23	V. slight.	Slight.	0.45	3.75	1.40	.0000	.0178	.0170	.0008	.56	.0030	.0000	.4479	0.9
13381	Nov. 27	V. slight.	Slight.	1.40	6.60	3.15	.0036	.0264	.0248	.0016	.66	.0110	.0000	1.6646	1.7
13548	Dec. 26	V. slight.	V. slight.	1.50	6.30	2.95	.0060	.0254	.0232	.0022	.64	.0080	.0000	1.2782	0.8
Av.	....	....	....	1.21	4.80	2.18	.0012	.0194	.0178	.0016	.53	.0058	.0000	.9882	1.0

Averages by Years.

-	1887*	-	-	1.37	5.16	1.95	.0021	.0296	-	-	.56	.0137	-	-	-
-	1888	-	-	1.48	5.19	2.32	.0014	.0254	-	-	.53	.0183	.0001	-	-
-	1889	-	-	1.51	3.96	1.74	.0014	.0241	.0206	.0035	.50	.0103	.0001	-	-
-	1890	-	-	1.48	5.01	2.41	.0013	.0232	.0195	.0037	.45	.0125	.0001	-	1.2
-	1891	-	-	0.95	3.90	1.81	.0005	.0197	.0171	.0026	.42	.0103	.0000	-	0.8
-	1892	-	-	1.10	4.87	2.24	.0006	.0227	.0194	.0033	.52	.0108	.0001	-	1.0
-	1893	-	-	1.35	5.05	2.36	.0022	.0224	.0189	.0035	.51	.0051	.0001	1.0440	1.0
-	1894	-	-	1.21	4.80	2.18	.0012	.0194	.0178	.0016	.53	.0058	.0000	.9882	1.0

* June to December.

NOTE to analyses of 1894: Odor, generally distinctly vegetable, sometimes also mouldy or unpleasant. —— The samples were collected from the conduit at its entrance to the receiving reservoir, and represent water from the storage reservoir. Water from Little Quittacas Pond was drawn into the storage reservoir from June 22 to August 14, inclusive, and from August 18 to September 25, inclusive.

NEW BEDFORD.

Microscopical Examination of Water from the Conduit of the New Bedford Water Works.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	July	July	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	25	27	30	24	23	2	25	22	27	24	28	27
Number of sample,	11675	11806	11955	12088	12265	12448	12598	12784	13031	13187	13381	13548
PLANTS.												
Diatomaceæ, Synedra,	2	0	pr.	36	10	1	2	0	0	1	4	0
Cyanophyceæ,	0	0	0	0	0	8	448	14	0	8	0	0
Merismopedia,	0	0	0	0	0	8	448	14	0	0	0	0
Microcystis,	0	0	0	0	0	0	0	0	0	8	0	0
Algæ,	0	0	0	0	0	29	4	72	0	8	0	0
Chlorococcus,	0	0	0	0	0	29	4	0	0	8	0	0
Protococcus,	0	0	0	0	0	0	0	72	0	0	0	0
Fungi, Crenothrix,	pr.	0	1	84	1	15	18	9	4	7	4	0
ANIMALS.												
Infusoria,	21	12	3	0	1	0	0	0	3	0	0	0
Dinobryon,	5	5	0	0	0	0	0	0	0	0	0	0
Dinobryon cases,	14	7	1	0	1	0	0	0	0	0	0	0
Glenodinium,	0	0	2	0	0	0	0	0	0	0	0	0
Peridinium,	2	pr.	0	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	0	3	0	0	0
Miscellaneous, Zoöglœa,	30	8	42	440	84	15	28	84	15	16	128	0
TOTAL,	53	20	46	560	96	68	500	179	22	40	136	0

Chemical Examination of Water from Little Quittacas Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11957	Mar. 27	Slight.	Slight.	0.12	2.75	0.80	.0000	.0152	.0118	.0034	.45	.0030	.0000	.3465	0.8
12446	June 28	Distinct.	Slight, green.	0.20	3.05	1.05	.0002	.0186	.0168	.0018	.48	.0000	.0000	.3426	0.6
13029	Sept. 25	V. slight.	Cons.	0.18	2.95	1.00	.0004	.0158	.0120	.0038	.50	.0000	.0000	.2787	0.5
13547	Dec. 26	V. slight.	V. slight.	0.20	2.90	0.95	.0000	.0166	.0142	.0024	.49	.0000	.0000	.2618	0.8
Av.	....	....	....	0.18	2.91	0.95	.0002	.0165	.0137	.0028	.48	.0008	.0000	.3074	0.7

Averages by Years.

–	1887*	–	–	0.23	2.92	1.16	.0003	.0149	–	–	.51	.0035	–	–	–
–	1888†	–	–	0.15	3.00	1.15	.0003	.0171	–	–	.48	.0035	.0001	–	–
–	1893	–	–	0.11	3.02	1.23	.0015	.0156	.0128	.0028	.48	.0025	.0000	.2904	0.6
–	1894	–	–	0.18	2.91	0.95	.0002	.0165	.0137	.0028	.48	.0008	.0000	.3074	0.7

* June and September. † January and May.

NOTE to analyses of 1894: Odor, vegetable. —— The samples were collected from the pond, about 800 feet from the southerly shore.

NEW BEDFORD.

Microscopical Examination of Water from Little Quittacas Pond, Lakeville.

[Number of organisms per cubic centimeter.]

	1894.			
	March.	July.	Sept.	Dec.
Day of examination,	30	2	26	27
Number of sample,	11957	12446	13029	13547
PLANTS.				
Diatomaceæ,	144	433	2	2
Asterionella,	80	428	0	0
Cyclotella,	26	0	1	1
Fragilaria,	2	0	0	0
Synedra,	30	5	1	1
Tabellaria,	6	pr.	0	0
Cyanophyceæ, Anabæna,	0	2	26	0
Algæ,	8	3	0	0
Chlorococcus,	0	3	0	0
Protococcus,	8	0	0	0
ANIMALS.				
Infusoria,	68	22	1	0
Dinobryon cases,	68	0	0	0
Peridinium,	pr.	22	0	0
Trachelomonas,	0	pr.	1	0
Crustacea, Cyclops,	.01	0	.01	0
Miscellaneous,	8	24	17	0
Acarina,	.02	0	0	0
Zoöglœa,	8	24	17	0
TOTAL,	228	484	46	2

Table showing Heights of Water in Acushnet Reservoir and Little Quittacas Pond on Dates when Samples of Water were collected for Analysis.

1894.	Acushnet Reservoir. Distance below High-water Mark.	Little Quittacas Pond. Distance below High-water Mark.	1894.	Acushnet Reservoir. Distance below High-water Mark.	Little Quittacas Pond. Distance below High-water Mark.
	Feet.	Feet.		Feet.	Feet.
Jan. 24,	0.08	1.42	July 24,	0.75	2.33
Feb. 26,	0.00	0.75	Aug. 20,	1.00	3.67
March 27,	0.00	0.83	Sept. 25,	0.50	5.50
April 23,	0.00	0.83	Oct. 23,	0.75	5.00
May 21,	0.25	1.33	Nov. 27,	0.17	3.67
June 28,	0.50	1.50	Dec. 26,	0.00	0.58

NEW BEDFORD.

Chemical Examination of Water from Great Quittacas Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11956	Mar. 27	V. slight.	V. slight.	0.50	3.20	1.15	.0000	.0166	.0154	.0012	.47	.0030	.0000	.5082	0.5
12447	June 28	Slight.	V. slight.	0.67	3.85	2.00	.0000	.0172	.0156	.0016	.49	.0000	.0000	.6006	0.6
13028	Sept. 25	V. slight.	V. slight.	0.30	2.85	0.90	.0006	.0124	.0108	.0016	.54	.0020	.0000	.4004	0.6
Av.	1894	....	....	0.49	3.30	1.35	.0002	.0154	.0139	.0015	.50	.0017	.0000	.5031	0.6
Av.	1893*	....	....	0.85	3.65	1.92	.0000	.0166	.0144	.0022	.43	.0018	.0000	.7812	0.3

* Five samples, July to September.

Odor, vegetable, of the second sample not as strong as of the other two. —— The samples were collected from the pond, 600 to 1,000 feet from the southwesterly shore.

Microscopical Examination of Water from Great Quittacas Pond, Lakeville.

[Number of organisms per cubic centimeter.]

	1894.		
	March.	July.	September.
Day of examination,	30	2	26
Number of sample,	11956	12447	13028
PLANTS.			
Diatomaceæ,	**136**	**13**	**0**
Asterionella,	102	3	0
Cyclotella,	4	9	0
Synedra,	30	1	0
Cyanophyceæ,	**0**	**4**	**8**
Chroöcoccus,	0	3	0
Microcystis,	0	1	8
Algæ, Chlorococcus,	**1**	**10**	**0**
Fungi, Crenothrix,	**0**	**0**	**2**
ANIMALS.			
Infusoria,	**8**	**0**	**12**
Dinobryon cases,	5	0	0
Peridinium,	3	0	12
Vermes, Monocerca,	**0**	**0**	**1**
Miscellaneous, Zoöglœa,	**0**	**10**	**2**
TOTAL,	145	37	35

NEW BEDFORD.

Chemical Examination of Water from Long Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11958	Mar. 27	V. slight.	Slight.	1.05	4.00	1.75	.0006	.0166	.0150	.0016	.44	.0030	.0000	1.0010	0.6
12445	Apr. 28	V. slight.	V. slight.	1.20	4.10	2.30	.0000	.0178	.0160	.0018	.45	.0000	.0000	.9425	0.3
13030	Sept. 25	V. slight	Slight.	0.55	2.90	1.40	.0000	.0154	.0138	.0016	.46	.0020	.0000	.5221	0.5
13546	Dec. 26	V. slight.	Slight.	1.20	4.20	2.30	.0000	.0232	.0200	.0032	.52	.0000	.0000	1.1442	0.5
Av.	....	....	....	1.00	3.80	1.94	.0002	.0183	.0162	.0021	.47	.0013	.0000	.9025	0.5

Averages by Years.

-	1891*	-	-	0.55	3.15	1.62	.0000	.0130	.0114	.0016	.49	.0020	.0000	-	0.3
-	1893†	-	-	0.85	3.65	1.92	.0000	.0166	.0144	.0022	.43	.0018	.0000	.7812	0.3
-	1894	-	-	1.00	3.80	1.94	.0002	.0183	.0162	.0021	.47	.0013	.0000	.9025	0.5

* December, two samples. † July to September, five samples.

NOTE to analyses of 1894: Odor, distinctly vegetable. —— The samples were collected from the middle of the easterly cove, at the southerly end of the pond, about 1,000 feet from shore.

NEW BEDFORD.

Microscopical Examination of Water from Long Pond, Lakeville.

[Number of organisms per cubic centimeter.]

	1894.			
	March.	July.	September.	December.
Day of examination,	30	2	27	27
Number of sample,	11958	12445	13030	13546
PLANTS.				
Diatomaceæ,	**11**	**7**	**0**	**5**
Asterionella,	5	7	0	0
Melosira,	5	pr.	0	0
Navicula,	0	pr.	0	2
Synedra,	1	0	0	3
Cyanophyceæ, Microcystis,	**0**	**5**	**7**	**0**
Algæ,	**14**	**3**	**0**	**0**
Chlorococcus,	4	3	0	0
Protococcus,	10	0	0	0
ANIMALS.				
Infusoria,	**64**	**1**	**14**	**0**
Dinobryon cases,	64	pr.	0	0
Peridinium,	0	pr.	14	0
Trachelomonas,	0	1	0	0
Vermes, Anurea,	**0**	**pr.**	**1**	**0**
Miscellaneous, Zoöglœa,	**3**	**22**	**14**	**0**
TOTAL,	92	38	36	5

WATER SUPPLY OF NEWBURYPORT. — NEWBURYPORT WATER COMPANY.

The reply of the State Board of Health to an application of the Newburyport Water Company relative to increasing its sources of water supply by taking water from wells to be located upon the banks of the Artichoke River in Newburyport, may be found on pages 34 and 35 of this volume. Analyses of samples of water collected from test wells in the region in which it was proposed to locate the wells may be found on page 259.

The reply of the State Board of Health to an application of the Mayor of Newburyport for its opinion as to the probable efficiency

NEWBURYPORT.

of a filter constructed by the Newburyport Water Company for the filtration of water from the Merrimack River, and as to whether the river water thus filtered would be safe for drinking in the public schools or by the citizens of Newburyport, may be found on page 34 of this volume.

Chemical Examination of Water from a Faucet in Newburyport, supplied from the Works of the Newburyport Water Company.

[Parts per 100,000.

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11641	Jan. 16	V. slight, milky.	V. slight.	0.10	6.60	.0000	.0014	.44	.0200	.0000	.0156	2.5	.0320
11756	Feb. 14	Slight, milky.	None.	0.10	5.50	.0000	.0026	.44	.0200	.0000	.0352	2.1	.0500
11897	March 14	Slight, milky.	Slight, green.	0.15	5.20	.0006	.0054	.36	.0120	.0000	.1320	1.7	.0430
12062	April 17	Distinct, milky.	V. slight, white.	0.10	5.80	.0002	.0052	.52	.0120	.0000	.1131	2.2	.0420
12223	May 15	Slight.	Slight.	0.05	5.60	.0000	.0050	.42	.0050	.0000	.0920	2.1	.0140
12391	June 19	Slight.	Slight.	0.07	5.80	.0006	.0044	.47	.0070	.0000	.1063	2.3	.0170
12556	July 17	Slight.	Slight.	0.12	5.70	.0000	.0042	.50	.0080	.0000	.0847	2.5	.0340
12763	Aug. 15	Slight, milky.	V. slight.	0.20	6.00	.0000	.0048	.44	.0050	.0000	.1155	2.3	.0300
12983	Sept. 18	Slight, milky.	None.	0.20	7.30	.0000	.0026	.48	.0200	.0000	.0693	2.3	.0300
13143	Oct. 16	Slight, milky.	None.	0.20	6.70	.0000	.0064	.48	.0080	.0000	.1619	2.6	.0200
13342	Nov. 20	V. slight.	V. slight.	0.12	6.00	.0002	.0028	.51	.0180	.0000	.0796	2.5	.0350
13512	Dec. 18	Slight.	V. slight.	0.10	5.80	.0000	.0014	.46	.0250	.0000	.0269	2.3	.0220
Av.	....	....	....	0.13	6.00	.0001	.0039	.46	.0133	.0000	.0860	2.3	.0308

Averages by Years.

–	1887-88*	–	–	0.03	5.39	.0004	.0032	0.45	.0312	.0001	–	–	–
–	1893	–	–	0.11	8.50	.0013	.0048	3.44†	.0178	.0000	.1391	2.7	.0164
–	1894	–	–	0.13	6.00	.0001	.0039	0.46	.0133	.0000	.0860	2.3	.0308

* June, 1887, to May, 1888.

† The very high chlorine present in the water in 1893 was due to the use at times of water from the Merrimack River which contained a small amount of sea water.

NOTE to analyses of 1894: Odor, of Nos. 12223 and 13143, aromatic; of Nos. 12391, 12556, faintly vegetable; of the other samples, none. A distinctly unpleasant oily odor was developed in No. 11897 on heating. —— The samples were collected from a faucet at No. 2 State Street.

NEWBURYPORT.

Microscopical Examination of Water from a Faucet in Newburyport, supplied from the Works of the Newburyport Water Company.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	18	15	15	18	16	21	18	16	20	17	22	24
Number of sample,	11641	11756	11897	12062	12223	12391	12556	12763	12983	13143	13342	13512
PLANTS.												
Diatomaceæ,	**0**	**0**	**18**	**4**	**10**	**4**	**0**	**0**	**6**	**1**	**6**	**1**
Fragilaria,	0	0	2	0	3	4	0	0	3	0	0	0
Synedra,	0	0	16	4	7	pr.	0	0	3	1	6	1
Algæ, Protococcus,	**0**	**0**	**0**	**0**	**0**	**7**	**0**	**0**	**0**	**0**	**0**	**1**
ANIMALS.												
Infusoria,	**0**	**0**	**78**	**0**	**126**	**pr.**	**36**	**0**	**0**	**404**	**21**	**2**
Dinobryon,	0	0	14	0	2	0	0	0	0	0	3	0
Dinobryon cases,	0	0	64	0	106	0	0	0	0	400	18	2
Glenodinium,	0	0	0	0	16	0	0	0	0	0	0	0
Mallomonas,	0	0	0	0	0	0	36	0	0	0	0	0
Peridinium,	0	0	0	0	2	pr.	0	0	0	4	0	0
Miscellaneous, Zoöglœa,	**0**	**0**	**0**	**4**	**26**	**6**	**0**	**0**	**7**	**0**	**0**	**0**
TOTAL,	0	0	*96	8	162	17	36	0	13	405	27	4

* Disintegrated remains of some organism were present in large numbers in this sample.

NEWBURYPORT.

Chemical Examination of Water from Wells in the Valley of Artichoke River, East of the Old Newbury Road, Newburyport.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12472	July 5	Decided, milky.	Heavy, clay.	0.02	13.10	.0012	.0002	.44	.0000	.0000	.0000	6.4	.0100*
12473	July 5	Decided, milky.	Heavy, sandy.	0.03	5.10	.0004	.0002	.80	.0200	.0000	.0000	2.1	.0060*
12487	July 9	Distinct, milky.	Slight, rusty.	–	–	–	–	.84	–	–	–	–	.1750 .1400*
12488	July 9	Slight, milky.	Slight, rusty.	–	–	–	–	2.10	–	–	–	–	.5400 .1700*
12489	July 9	V. slight, milky.	Slight, rusty.	–	–	–	–	.41	–	–	–	–	.0550 .0550*
12490	July 9	V. slight.	V. slight.	–	–	–	–	1.15	–	–	–	–	.0070

* In each of these cases the amount of iron was determined after the water had been filtered through filter paper.

Odor of the first two samples, distinctly earthy. —— The samples, with the exception of the last, were collected from tubular test wells. The last sample was collected from an old well lined with a stone curbing.

Water Supply of Newton.

The works for obtaining ground water for the supply of the city of Newton were extended again in 1894, the extension in this case being made in a direction away from the river, whereas previous works were nearly parallel with the river. Beginning at the upper end of the system already in existence, the extension is a brick conduit for a distance of 90 feet, and beyond this conduit a double line of 24-inch drain pipe, laid with open joints, excepting at places where poor material, such as mud or quicksand, was encountered, where the joints were cemented. In places where there was a stratum of coarse, water-bearing gravel beneath the stratum in which the conduit was laid, 2½-inch wells were driven on either side and connected with it. The conduit is embedded in, and covered with screened gravel, forming a layer 2½ feet in thickness all around it. The total number of wells connected with the conduit is 52, and their average depth is about 35 feet. The total length of new conduit, including the brick section already mentioned, is 3,268 feet, and as the works previously constructed had a length of 2,795 feet, the total length of filter-gallery or conduit is now 7,050 feet.

NEWTON.

Chemical Examination of Water from a Faucet at the Newton Water Works Pumping Station.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11779	Feb. 19	None.	None.	0.00	6.35	.0000	.0008	.40	.0180	.0000	.0304	2.9	.0085
12273	May 22	V. slight.	Cons., rusty.	0.02	6.85	.0000	.0020	.36	.0200	.0000	.0406	3.2	.0500
12415	June 21	None.	None.	0.05	4.80	.0000	.0014	.36	.0150	.0000	.0539	2.2	.0055
12567	July 18	None.	None.	0.02	5.80	.0000	.0022	.40	.0190	.0000	.1116	2.2	.0100
12754	Aug. 15	Slight, milky.	Slight.	0.08	6.25	.0004	.0022	.34	.0150	.0000	.0485	3.0	.0040
13001	Sept. 19	None.	None.	0.02	6.50	.0000	.0030	.42	.0100	.0000	.0462	3.3	.0050
13168	Oct. 18	V. slight.	V. slight.	0.04	5.90	.0000	.0036	.41	.0100	.0000	.0671	2.3	.0060
13324	Nov. 19	None.	V. slight.	0.02	6.50	.0002	.0026	.47	.0120	.0000	.0452	2.9	.0070
13487	Dec. 17	None.	None.	0.03	5.00	.0000	.0014	.42	.0220	.0000	.0447	2.3	.0030
Av.	....	....	....	0.03	5.99	.0001	.0021	.40	.0157	.0000	.0542	2.7	.0110

Averages by Years.

–	1887*	–	–	0.00	4.97	.0005	.0070	.38	.0047	–	–	–	–
–	1888	–	–	0.01	4.64	.0009	.0111	.35	.0072	.0001	–	–	–
–	1889	–	–	0.00	3.93	.0002	.0061	.30	.0126	.0001	–	–	–
–	1890†	–	–	0.00	–	.0000	.0014	.32	.0250	.0001	–	–	–
–	1891†	–	–	0.00	4.25	.0002	.0072	.31	.0250	.0000	–	1.8	–
–	1892	–	–	0.02	5.13	.0006	.0028	.35	.0190	.0001	–	2.4	–
–	1893	–	–	0.03	5.08	.0004	.0019	.38	.0194	.0000	.0856	2.3	.0119
–	1894	–	–	0.03	5.99	.0001	.0021	.40	.0157	.0000	.0542	2.7	.0110

* June to December. † February.

NOTE to analyses of 1894: Odor, none. —— The samples were collected from a faucet at the pumping station.

Analyses for the years 1887 to 1890, inclusive, represent water drawn from an open filter-basin. In 1890 the works for collecting ground water were enlarged by the construction of a long wooden filter-gallery, reinforced by tubular wells. A portion of this gallery, 732 feet in length, replaced an equal portion of the old open filter-basin. In 1892 the remaining portion of the open filter-basin was replaced by an extension of the filter-gallery, and after December of that year the water pumped for the supply of the city was not exposed to light at any point. In 1894 the works were again enlarged, as described above.

NEWTON.

Microscopical Examination of Water from a Faucet at the Newton Water Works Pumping Station.

[Number of organisms per cubic centimeter.]

	1894.								
	Feb.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	24	23	18	16	21	19	20	18
Number of sample,	11779	12273	12415	12567	12754	13001	13168	13324	13487
PLANTS.									
Fungi, Crenothrix,	2	104	0	3	0	0	0	0	1
Miscellaneous, Zoöglœa,	1	4	0	0	4	10	0	0	0
TOTAL,	3	108	0	3	4	10	0	0	1

Chemical Examination of Water from the Covered Distributing Reservoir of the Newton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11780	Feb. 19	None.	Slight.	0.02	5.90	.0000	.0014	.40	.0120	.0000	.0440	2.9	.0210
12274	May 22	None.	V. slight.	0.03	5.70	.0000	.0012	.37	.0200	.0000	.0468	2.2	.0130
12416	June 21	V. slight.	V. slight.	0.03	5.40	.0002	.0026	.35	.0180	.0000	.0616	2.7	.0065
12566	July 18	Distinct.	Cons., brown.	0.00	7.50	.0002	.0070	.38	.0150	.0000	.0739	2.9	.0750
12755	Aug. 15	V. slight.	Slight, earthy.	0.04	7.55	.0000	.0026	.38	.0200	.0000	.0924	3.6	.0080
13002	Sept. 19	V. slight.	Cons., yellowish.	0.04	7.00	.0002	.0030	.34	.0100	.0000	.0539	3.1	.0300
13169	Oct. 18	Distinct, milky.	Slight, fibrous.	0.07	7.10	.0002	.0030	.44	.0080	.0000	.0766	3.1	.0300
13323	Nov. 19	Slight.	Cons., dark.	0.03	6.40	.0000	.0062	.48	.0130	.0000	.0975	3.2	.0600
13488	Dec. 17	V. slight.	Cons.	0.03	5.40	.0008	.0076	.46	.0180	.0000	.0654	2.3	.0730
Av.	....	....	....	0.03	6.44	.0002	.0038	.40	.0149	.0000	.0680	2.9	.0352

Averages by Years.

-	1892	-	-	0.03	6.40	.0022	.0038	.35	.0246	.0003	-	3.0	.0242
-	1893	-	-	0.04	6.40	.0000	.0027	.38	.0220	.0000	.0678	3.0	.0196
-	1894	-	-	0.03	6.44	.0002	.0038	.40	.0149	.0000	.0680	2.9	.0352

NOTE to analyses of 1894: Odor of No. 13169, very faintly vegetable; of No. 13323, distinct and unpleasant; of the other samples, none. In July a distinctly oily odor was developed on heating, and in December a distinctly unpleasant odor. —— The samples were collected from the reservoir.

NEWTON.

Microscopical Examination of Water from the Covered Distributing Reservoir of the Newton Water Works.

[Number of organisms per cubic centimeter.]

	1894. Feb.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	24	23	18	16	21	19	20	18
Number of sample,	11780	12274	12416	12566	12755	13002	13169	13323	13488
PLANTS.									
Fungi, Crenothrix,	40	3	7	312	34	11	9	1	44
Miscellaneous, Zoöglœa,	10	0	0	60	0	52	0	0	0
TOTAL,	50	3	7	372	34	63	9	1	44

Chemical Examination of Water from the Main Underdrain of the Hyde Brook Division of the Newton Sewerage System.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11912	Mar. 19	V. slight.	None.	0.00	22.90	.0070	.0032	2.33	1.0000	.0004	.0497	8.7	.0050
12584	July 18	None.	V. slight.	0.05	30.80	.0052	.0022	3.00	.9300	.0021	.0115	9.0	.0050
13305	Nov. 14	V. slight.	Slight.	0.03	25.10	.0192	.0048	2.68	1.0500	.0011	.0741	10.0	.0000
Av.	....	....	....	0.03	26.27	.0105	.0034	2.67	.9933	.0012	.0451	9.2	.0033

Averages by Years.

-	1891*	-	-	0.00	26.05	.0200	.0036	3.15	1.5000	.0050	-	10.7	-
-	1892	-	-	0.00	27.08	.0126	.0029	3.18	1.1666	.0015	-	10.1	.0052
-	1893	-	-	0.03	25.43	.0140	.0037	2.48	.9550	.0018	.0640	9.4	.0099
-	1894	-	-	0.03	26.27	.0105	.0034	2.67	.9933	.0012	.0451	9.2	.0033

* December.

NOTE to analyses of 1894: Odor of the first and second samples, none; of the third, faintly musty, disappearing on heating. —— The samples were collected from the underdrain, at its outlet.

Microscopical Examination.

No. 11912. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoöglœa*, 8. Total, 11.
No. 12584. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoöglœa*, 18. Total, 21.
No. 13305. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoöglœa*, 52. Total, 55.

NEWTON.

Chemical Examination of Water from the Main Underdrain of the Cheesecake Brook Division of the Newton Sewerage System.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11911	Mar. 19	Distinct.	Cons., yellow.	0.08	18.90	.0102	.0022	1.25	.2200	.0001	.0474	7.7	.0920
12585	July 18	V. slight.	V. slight.	0.03	20.60	.0188	.0024	2.40	.6500	.0080	.0385	7.1	.0100
13306	Nov. 14	V. slight.	V. slight.	0.00	22.10	.0506	.0074	2.51	.8000	.0008	.0608	8.9	.0000
Av.	1894	....	....	0.04	20.53	.0265	.0040	2.05	.5567	.0030	.0489	7.9	.0340
Av.	1893*	....	....	0.08	15.83	.0075	.0016	1.51	.3225	.0006	.0217	6.0	.0520

* July to December.

NOTE to analyses of 1894: Odor of the first and second samples, none; of the third, decided. —— The samples were collected from the underdrain, at its outlet.

Microscopical Examination.

No. 11911. Fungi, *Crenothrix*, 480. Miscellaneous, *Zoöglœa*, 2. Total, 482.
No. 12585. Fungi, *Crenothrix*, 108. Miscellaneous, *Zoöglœa*, 13. Total, 121.
No. 13306. Diatomaceæ, *Melosira*, 4. Fungi, *Crenothrix*, 5. Total, 9.

Chemical Examination of Water from the Main Underdrain Beneath the Laundry Brook Valley Sewer, Newton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11913	Mar. 19	Distinct.	Cons., yellow.	0.08	17.20	.0098	.0020	1.68	.4000	.0003	.0790	7.1	.0700
12583	July 18	Slight.	Slight, yellow.	0.03	18.00	.0102	.0012	1.60	.3500	.0010	.0308	6.7	.0280
13304	Nov. 14	Slight.	Cons.	0.01	16.50	.0108	.0024	1.75	.3800	.0002	.0429	6.7	.0360
Av.	1894	....	....	0.04	17.23	.0103	.0019	1.68	.3767	.0005	.0509	6.8	.0447
Av.	1893*	....	....	0.08	16.90	.0082	.0026	1.51	.3500	.0006	.0782	7.1	.0525

* October and December.

Odor, none. —— The samples were collected from the underdrain, at its outlet.

Microscopical Examination.

No. 11913. Fungi, *Crenothrix*, 4,000.
No. 12583. Fungi, *Crenothrix*, 480. Miscellaneous, *Zoöglœa*, 14. Total, 494.
No. 13304. Fungi, *Crenothrix*, 1,900.

NEWTON.

Chemical Examination of Water from Test Wells in Needham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12006	April 7	Decided.	Heavy, sandy.	0.02	3.90	.0028	.0018	.43	.0600	.0003	.0240	1.1	.0050
12007	April 7	Distinct.	Cons., sandy.	0.00	6.60	.0000	.0010	.75	.3500	.0000	.0080	2.3	.0030

Odor, none. —— The samples were collected from test wells in land taken by the city of Newton for water-supply purposes, to determine whether the water was polluted by a piggery upon the land.

Microscopical Examination.

No. 12006. Fungi, *Crenothrix*, 5.
No. 12007. No organisms.

Water Supply of Northampton.

In 1894 a new storage reservoir was constructed on Roberts' Meadow Brook between the upper and lower reservoirs constructed in previous years, the dam being located about 500 feet above the upper end of the lower reservoir. The new reservoir has an area of 26 acres and a capacity of 84,000,000 gallons, which can be increased to 114,000,000 gallons by means of flash-boards 3 feet in height. Its greatest depth is 30 feet, and its average depth at ordinary high-water mark 9.9 feet. The reservoir was prepared for the storage of water by the removal of the soil, stumps and vegetable matter from the area flowed. Provision has been made for drawing water from the brook above this reservoir directly to the city if desired.

NORTHAMPTON.

Chemical Examination of Water from the Upper Storage Reservoir of the Northampton Water Works on Roberts' Meadow Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12684	Aug. 7	V. slight.	Slight.	0.10	5.05	2.00	.0008	.0048	.0040	.0008	.12	.0060	.0001	.1001	2.2
12887	Sept. 5	Slight.	Slight.	0.10	5.15	1.10	.0088	.0080	.0052	.0028	.12	.0050	.0002	.1001	2.1

Odor, faintly vegetable. —— The samples were collected from the reservoir.

Microscopical Examination.

No. 12684. Diatomaceæ, *Cyclotella*, 36; *Cymbella*, 1; *Diatoma*, 1; *Fragilaria*, 21; *Melosira*, 2; *Synedra*, 7. Cyanophyceæ, *Microcystis*, 1. Algæ, *Glœocapsa*, 1; *Staurastrum*, 1. Fungi, *Beggiatoa*, 1. Infusoria, *Dinobryon cases*, 7. Total, 79.

No. 12887. Diatomaceæ, *Cyclotella*, 9; *Cymbella*, 2; *Diatoma*, 1; *Epithemia*, 1; *Gomphonema*, 1; *Navicula*, 1; *Pinnularia*, 1; *Synedra*, 22. Algæ, *Arthrodesmus*, 3; *Scenedesmus*, 9; *Staurastrum*, 3. Fungi, *Crenothrix*, 3. Infusoria, *Dinobryon cases*, 6; *Monas*, 1; *Peridinium*, 1. Miscellaneous, *Zoöglœa*, 6. Total, 70.

Chemical Examination of Water from the Lower Storage Reservoir of the Northampton Water Works on Roberts' Meadow Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12685	Aug. 8	Slight.	Slight.	0.20	4.70	0.90	.0002	.0114	.0078	.0036	.12	.0000	.0001	.1548	2.3
12888	Sept. 5	Distinct.	Slight.	0.23	6.65	1.45	.0000	.0178	.0106	.0072	.13	.0000	.0000	.2541	2.9

Odor, faintly vegetable. —— The samples were collected from the reservoir.

Microscopical Examination.

No. 12685. Diatomaceæ, *Cyclotella*, 1040; *Cymbella*, 2; *Fragilaria*, 4; *Navicula*, 2; *Synedra*, 60. Algæ, *Arthrodesmus*, 1; *Polyedrium*, 1. Fungi, *Crenothrix*, 28. Rhizopoda, *Difflugia*, 1. Infusoria, *Dinobryon cases*, 22. Total, 1,161.

No. 12888. Diatomaceæ, *Cyclotella*, 156; *Navicula*, 3; *Pinnularia*, 1; *Synedra*, 388; *Tabellaria*, 1. Algæ, *Cœlastrum*, 1; *Cosmarium*, 1; *Pandorina*, 1; *Pediastrum*, 9; *Scenedesmus*, 2. Fungi, *Crenothrix*, 2. Vermes, *Triarthra*, 1. Miscellaneous, *Acarina*, .01; *Zoöglœa*, 13. Total, 579.

NORTH ATTLEBOROUGH.

Water Supply of North Attleborough.

The advice of the State Board of Health to the town of North Attleborough, relative to a proposed additional water supply for the town, may be found on pages 35 and 36 of this volume. Analyses of samples of water collected in connection with the investigation of the proposed sources of additional supply may be found on pages 267 and 268.

Chemical Examination of Water from the Wells of the North Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11704	Feb. 2	V. slight, milky.	None.	0.00	6.00	.0000	.0000	.61	.0550	.0002	.0284	2.6	.0140
12655	Aug. 3	V. slight.	None.	0.05	7.10	.0010	.0006	.68	.0090	.0001	.0000	3.1	.0050
12984	Sept. 18	V. slight, milky.	V. slight.	0.08	7.80	.0008	.0000	.80	.0400	.0000	.0154	3.8	.0300
13136	Oct. 15	Slight, milky.	V. slight.	0.07	7.20	.0012	.0024	.76	.0700	.0001	.0213	3.0	.0380
13470	Dec. 11	None.	None.	0.00	6.10	.0014	.0022	.67	.0800	.0000	.0192	2.9	.0020
Av.	....	....	....	0.04	6.84	.0009	.0010	.70	.0508	.0001	.0169	3.1	.0178

Averages by Years.

-	1887*	-	-	0.00	6.28	.0001	.0011	.50	.0290	-	-	-	-
-	1888	-	-	0.00	6.27	.0002	.0018	.50	.0288	.0000	-	-	-
-	1889†	-	-	0.00	6.09	.0000	.0012	.55	.0414	.0000	-	-	-
-	1892‡	-	-	0.00	5.95	.0008	.0018	.53	.0416	.0000	-	3.0	-
-	1893§	-	-	0.00	5.88	.0003	.0005	.60	.0450	.0000	.0109	2.8	.0040
-	1894	-	-	0.04	6.84	.0009	.0010	.70	.0508	.0001	.0169	3.1	.0178

* June to December. † January to May. ‡ April to December. § March and July.

NOTE to analyses of 1894: No. 12655 had a faint odor of sulphuretted hydrogen, becoming distinct on heating. There was no odor in the other samples. On heating, a distinct marshy odor was developed in No. 12984. —— The samples were collected either from the well or from a faucet at the pumping station.

Microscopical Examination.

No. 11704. Miscellaneous, *Zoöglœa*, 1.
No. 12984. Miscellaneous, *Zoöglœa*, 22.
No organisms were found in the remaining samples.

NORTH ATTLEBOROUGH.

Chemical Examination of Water from Faucets in North Attleborough, supplied from the North Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11705	Feb. 2	None.	None.	0.00	5.90	.0000	.0004	.61	.0600	.0000	.0000	2.6	.0050
12654	Aug. 3	None.	None.	0.02	8.00	.0010	.0000	.68	.0100	.0001	.0000	3.4	.0040
13469	Dec. 11	None.	None.	0.00	6.00	.0008	.0030	.65	.0750	.0001	.0023	3.0	.0050

Odor, none. —— The samples were collected from faucets in the town.

Microscopical Examination.

No organisms.

Chemical Examination of Water from Test Wells in the Vicinity of the Pumping Station of the North Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as.		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12937	Sept. 12	Decided, clayey.	Heavy, rusty.	0.12	6.20	.0000	.0002	.25	.0000	.0000	.0308	2.9	.2400
12938	Sept. 12	Distinct, clayey.	Cons., earthy.	0.02	6.20	.0000	.0004	.71	.0100	.0000	.0308	2.6	.0280
12939	Sept. 12	None.	Slight, rusty.	0.00	6.50	.0004	.0000	.27	.0000	.0000	.0462	3.1	.1450
12940	Sept. 12	None.	Cons., rusty.	0.50	4.80	.0000	.0000	.27	.0000	.0000	.1001	3.0	.2500

Odor of the first sample, faintly tarry; of the others, none. —— The samples were collected in the order of their numbers from test wells numbered 2, 4, 6 and 9. The wells were distant between 300 and 900 feet in a northerly direction from the present source of supply.

Microscopical Examination.

No organisms.

NORTH ATTLEBOROUGH.

Chemical Examination of Water from the Ten Mile River above the Village of Plainville in Wrentham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12941	Sept.12	Slight.	Slight.	0.25	3.45	1.00	.0000	.0098	.0076	.0022	.24	.0000	.0001	.2233	0.6

Odor, distinctly mouldy. —— The sample was collected from the river at Fuller's Dam.

Microscopical Examination.

Miscellaneous, *Zoöglœa*, 1.

WATER SUPPLY OF NORTHBOROUGH.

Chemical Examination of Water from the Upper Reservoir of the Northborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12596	July 24	Decided, green.	Cons., green.	0.70	4.00	2.10	.0000	.0542	.0192	.0350	.30	.0040	.0001	.6198	1.1
12774	Aug.17	Distinct.	Slight.	0.70	4.85	2.35	.0008	.0284	.0250	.0034	.30	.0000	.0000	.5559	0.8

Odor, distinctly vegetable. —— The samples were collected from the reservoir.

Microscopical Examination.

No. 12596. Algæ, *Eudorina*, 50; *Pandorina*, 8; *Protococcus*, 200. Infusoria, *Ciliated infusorian*, 300; *Peridinium*, 200. Total, 758.

No. 12774. Diatomaceæ, *Melosira*, 4; *Navicula*, 1; *Synedra*, 72. Cyanophyceæ, *Anabæna*, 3. Algæ, *Pediastrum*, 2; *Protococcus*, 15; *Scenedesmus*, 1. Fungi, *Crenothrix*, 2. Infusoria, *Euglena*, 1; *Monas*, 1; *Peridinium*, 148. Miscellaneous, *Zoöglœa*, 44. Total, 294.

NORTHBOROUGH.

Chemical Examination of Water from the Lower Reservoir of the Northborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
12597	July 24	Distinct, green.	Cons., yellow.	0.60	3.95	1.60	.0018	.0338	.0228	.0110	.28	.0000	.0000	.5760	0.8
12775	Aug. 17	Distinct, green.	Cons., green.	0.55	2.45	1.45	.0000	.0336	.0208	.0128	.26	.0000	.0000	.4990	1.0

Odor, distinctly vegetable, and of the second sample, also oily. —— The samples were collected from the reservoir.

Microscopical Examination.

No. 12597. Diatomaceæ, *Cymbella*, 1; *Diatoma*, 4; *Melosira*, 260; *Striatella*, 1; *Synedra*, 184; *Tabellaria*, 1,320. Cyanophyceæ, *Anabæna*, 16; *Rivularia*, 1. Algæ, *Arthrodesmus*, 1; *Closterium*, 1; *Staurastrum*, 520. Fungi, *Crenothrix*, 1. Rhizopoda, *Difflugia*, 5. Infusoria, *Dinobryon cases*, 12; *Peridinium*, 17; *Phacus*, 1; *Trachelomonas*, 1. Vermes, *Anurea*, 2; *Polyarthra*, 2. Crustacea, *Daphnia*, .02. Miscellaneous, *Acarina*, .02. Total, 2,350.

No. 12775. Diatomaceæ, *Melosira*, 25; *Tabellaria*, 320. Algæ, *Micrasterias*, 1. Infusoria, *Peridinium*, 44; *Syncrypta volvox*, 80. Vermes, *Anurea*, 70; *Polyarthra*, 7. Crustacea, *Cyclops*, 1. Total, 548.

Water Supply of North Brookfield.

Chemical Examination of Water from Doane Pond, North Brookfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11646	Jan. 17	Distinct.	Slight.	0.65	4.00	1.30	.0002	.0230	.0134	.0096	.22	.0050	.0000	.4914	1.1
11742	Feb. 12	Distinct.	Cons.	0.35	5.05	1.30	.0076	.0208	.0162	.0046	.24	.0120	.0000	.3856	1.6
11916	Mar. 19	Distinct.	V. slight.	0.30	2.70	1.05	.0004	.0236	.0182	.0054	.15	.0050	.0000	.3634	0.6
12014	Apr. 10	Distinct.	Slight.	0.30	3.05	1.05	.0010	.0308	.0256	.0052	.20	.0030	.0000	.3934	0.8
12179	May 9	Distinct.	Slight.	0.53	3.60	1.60	.0012	.0264	.0220	.0044	.17	.0030	.0000	.6068	0.9
12355	June 12	Slight.	Slight.	1.20	4.20	2.00	.0038	.0324	.0284	.0040	.16	.0000	.0000	.7969	1.3
12538	July 16	Distinct.	Slight.	1.50	4.70	2.30	.0028	.0380	.0300	.0080	.19	.0000	.0004	.7538	1.4
12759	Aug. 15	Distinct, green.	Slight, yellow.	1.30	4.85	2.30	.0026	.0410	.0326	.0084	.14	.0070	.0000	.7084	1.4
12972	Sept. 18	Distinct.	Cons., fibrous.	1.30	4.30	2.00	.0022	.0488	.0344	.0144	.18	.0000	.0000	.7777	0.9
13152	Oct. 17	Slight.	Cons., brown.	1.30	4.10	2.10	.0248	.0368	.0300	.0068	.17	.0000	.0002	.7758	0.6
13367	Nov. 22	Distinct.	Slight.	1.25	4.85	2.10	.0448	.0580	.0456	.0124	.16	.0170	.0003	.7800	1.4
13520	Dec. 19	Slight.	V. slight.	0.90	5.50	2.10	.0498	.0436	.0390	.0046	.24	.0130	.0002	.5967	1.7
Av.	....	....	....	0.91	4.24	1.77	.0110	.0353	.0280	.0073	.19	.0054	.0001	.6192	1.1

Iron, .0477. Odor, generally distinctly vegetable, sometimes also mouldy, unpleasant or disagreeable. —— The samples were collected from the pond, near the filter.

NORTH BROOKFIELD.

Microscopical Examination of Water from Doane Pond, North Brookfield.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	18	13	20	11	11	14	17	16	19	18	23	20
Number of sample,	11646	11742	11916	12014	12179	12355	12538	12759	12972	13152	13367	13520
PLANTS.												
Diatomaceæ,	**23**	**3**	**132**	**220**	**154**	**28**	**30**	**145**	**59**	**166**	**25**	**0**
Asterionella,	0	0	0	6	83	4	28	144	17	116	11	0
Cyclotella,	0	0	20	pr.	1	3	0	0	0	0	0	0
Desmidium,	0	0	0	0	6	0	0	0	0	0	0	0
Diatoma,	0	0	pr.	0	0	0	0	0	5	2	0	0
Fragilaria,	0	0	0	0	6	0	0	0	0	0	0	0
Navicula,	0	0	0	0	0	0	0	1	1	2	3	0
Synedra,	1	3	26	120	40	1	2	0	20	32	5	0
Tabellaria,	22	0	86	94	24	20	0	0	16	14	6	0
Cyanophyceæ, Chroöcoccus,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**0**	**0**	**0**
Algæ,	**50**	**3**	**2**	**6**	**19**	**94**	**28**	**478**	**259**	**42**	**19**	**0**
Arthrodesmus,	1	0	0	0	2	0	5	3	15	1	1	0
Botrycoccus,	0	0	0	0	0	10	0	0	0	0	0	0
Chlorococcus,	0	0	0	5	0	19	5	0	0	0	0	0
Cosmarium,	48	0	0	pr.	1	3	0	0	0	0	0	0
Dictyosphærium,	0	0	0	0	1	0	6	0	0	3	0	0
Hyalotheca,	0	0	0	0	0	15	0	0	0	0	0	0
Protococcus,	0	0	2	0	0	0	6	456	75	4	10	0
Raphidium,	0	0	0	0	10	0	6	10	164	4	4	0
Scenedesmus,	0	0	0	0	1	1	0	1	5	6	2	0
Selenastrum,	0	0	0	0	0	0	0	0	0	24	0	0
Staurastrum,	0	0	0	1	4	44	0	0	0	0	0	0
Staurogenia,	0	0	0	0	0	0	0	8	0	0	2	0
Zoöspores,	1	3	pr.	pr.	0	2	0	0	0	0	0	0
Fungi, Crenothrix,	**0**	**1**	**5**	**pr.**	**200**	**48**	**48**	**2**	**0**	**0**	**1**	**1**
ANIMALS.												
Rhizopoda,	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**
Actinophrys,	0	0	6	0	0	0	0	0	0	0	0	0
Arcella,	0	0	0	0	0	0	0	0	6	0	0	0
Infusoria,	**331**	**93**	**119**	**220**	**1,523**	**32**	**276**	**6**	**149**	**3**	**16**	**25**
Dinobryon,	44	0	80	58	0	5	6	0	3	0	8	0
Dinobryon cases,	2	0	0	100	1,520	25	268	0	8	0	5	1
Euglena,	1	0	0	3	0	0	0	0	0	0	0	3
Mallomonas,	0	0	0	0	0	2	0	0	0	0	0	0
Monas,	0	1	1	0	0	0	0	0	0	0	0	0
Peridinium,	264	92	36	40	1	0	0	1	0	0	3	21
Phacus,	0	0	0	0	0	0	0	1	132	0	0	0
Synura,	20	0	2	16	2	0	0	0	0	0	0	0
Tintinnidium,	0	0	pr.	3	0	0	0	4	0	2	0	0
Trachelomonas,	0	0	0	0	0	0	2	0	6	1	0	0
Vermes,	**0**	**1**	**pr.**	**5**	**1**	**2**	**2**	**2**	**4**	**1**	**0**	**0**
Anurea,	0	0	0	1	1	0	0	0	1	1	0	0
Monocerca,	0	0	0	0	0	1	0	0	1	0	0	0
Polyarthra,	0	0	0	pr.	0	1	1	2	0	0	0	0
Rotatorian ova,	0	0	pr.	2	0	0	0	0	0	0	0	0
Rotifer,	0	1	0	2	0	0	1	0	2	0	0	0
Miscellaneous,	**0**	**0**	**4**	**.05**	**520**	**0**	**.03**	**0**	**132**	**360**	**0**	**0**
Acarina,	0	0	.01	.05	0	0	.03	0	.32	0	0	0
Zoöglœa,	0	0	4	0	520	0	0	0	132	360	0	0
TOTAL,	404	101	268	451	2,417	204	384	633	618	572	61	26

NORTH BROOKFIELD.

Chemical Examination of Water from the Filtered-water Well of the North Brookfield Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11743	Feb. 12	Slight.	V. slight.	0.35	4.70	–	.0058	.0126	–	–	.24	.0100	.0000	.3664	1.6
11917	Mar. 19	Distinct.	V. slight.	0.23	3.40	1.05	.0004	.0176	.0132	.0044	.16	.0100	.0001	.3120	1.4
12015	Apr. 10	Distinct.	V. slight.	0.32	3.60	–	.0004	.0166	–	–	.16	.0070	.0001	.3571	1.3
12180	May 9	V. slight.	V. slight.	0.30	3.80	1.40	.0026	.0160	.0144	.0016	.16	.0050	.0001	.4248	1.8
12356	June 12	Slight.	Slight.	0.90	4.50	1.45	.0014	.0272	.0242	.0030	.13	.0030	.0001	.6468	1.3
12539	July 16	Slight.	Slight.	1.20	5.60	2.25	.0044	.0336	.0292	.0044	.26	.0030	.0003	.6560	1.9
12758	Aug. 15	Slight.	Slight.	0.80	5.40	2.40	.0198	.0172	.0154	.0018	.16	.0050	.0001	.5467	1.9
12973	Sept. 18	Slight.	Cons.	1.00	5.20	2.40	.0108	.0362	.0310	.0052	.19	.0020	.0002	.6622	1.4
13153	Oct. 17	Slight.	Slight, brown.	0.90	5.40	2.10	.0092	.0274	.0244	.0030	.20	.0080	.0002	.6478	2.3
13368	Nov. 22	Distinct.	Slight.	1.28	4.70	1.90	.0360	.0446	.0422	.0024	.21	.0230	.0003	.7800	1.4
13521	Dec. 19	Slight.	Slight.	0.70	5.15	1.80	.0146	.0378	.0326	.0052	.19	.0280	.0011	.5698	1.8
Av.	......	....	....	0.73	4.68	1.86	.0096	.0286*	.0252	.0034	.19	.0095	.0002	.5427	1.6

* Exclusive of Nos. 11743 and 12015.

Iron, .0498. Odor, generally vegetable, becoming stronger on heating; in May, none. —— The samples were collected from the filtered-water well.

NORTH BROOKFIELD.

Microscopical Examination of Water from the Filtered-water Well of the North Brookfield Water Works.

[Number of organisms per cubic centimeter.]

	1894.										
	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	13	20	11	11	14	17	16	19	18	23	20
Number of sample,	11743	11917	12015	12180	12356	12539	12758	12973	13153	13368	13521
PLANTS.											
Diatomaceæ,	**0**	**51**	**58**	**pr.**	**22**	**8**	**0**	**15**	**1**	**15**	**0**
Asterionella,	0	0	3	0	12	4	0	8	0	12	0
Melosira,	0	2	1	0	8	0	0	0	0	0	0
Synedra,	0	42	20	pr.	0	4	0	2	1	2	0
Tabellaria,	0	7	34	0	2	0	0	5	0	1	0
Algæ,	**1**	**5**	**1**	**pr.**	**70**	**13**	**80**	**14**	**0**	**0**	**0**
Chlorococcus,	0	0	0	0	6	0	0	0	0	0	0
Closterium,	0	4	0	0	3	0	0	0	0	0	0
Cosmarium,	1	0	1	0	5	0	0	0	0	0	0
Hyalotheca,	0	0	0	0	16	0	0	0	0	0	0
Protococcus,	0	1	0	0	31	12	72	2	0	0	0
Raphidium,	0	0	0	0	0	0	0	12	0	0	0
Staurastrum,	0	0	0	pr.	9	1	0	0	0	0	0
Staurogenia,	0	0	0	0	0	0	8	0	0	0	0
Fungi, Crenothrix,	**16**	**48**	**pr.**	**320**	**32**	**48**	**44**	**2**	**12**	**1**	**0**
ANIMALS.											
Infusoria,	**3**	**22**	**60**	**140**	**10**	**69**	**7**	**20**	**0**	**4**	**5**
Dinobryon cases,	pr.	2	26	140	8	40	0	0	0	1	0
Euglena,	0	0	pr.	0	0	0	0	0	0	0	4
Mallomonas,	0	0	0	0	2	0	1	0	0	0	0
Peridinium,	3	20	34	0	0	1	0	1	0	0	1
Phacus,	0	0	0	0	0	0	1	2	0	0	0
Tintinnidium,	pr.	0	0	0	0	0	1	0	0	2	0
Trachelomonas,	0	0	0	0	0	28	4	17	0	1	0
Vermes, Rotifer,	**0**	**pr.**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**
Crustacean remains,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**.16**	**0**	**0**	**0**
Miscellaneous,	**4**	**1**	**0**	**0**	**10**	**96**	**260**	**192**	**440**	**0**	**0**
Acarina,	0	0	0	0	0	0	0	.08	0	0	0
Zoöglœa,	4	1	0	0	10	96	260	192	440	0	0
TOTAL,	24	127	119	460	144	234	392	243	453	20	5

NORTON.

The reply of the State Board of Health to certain petitioners in the town of Norton, relative to a water supply for a proposed fire district in that town, to be obtained either from sources in the town or from the works of the towns of Attleborough or Mansfield, may be found on pages 36–38 of this volume. Analyses of samples of water from various sources in the town are given below.

Chemical Examination of Water from the Rumford and Wading Rivers, Norton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13439	Dec. 5	Slight.	V. slight.	0.67	4.80	1.60	.0016	.0150	.0100	.0050	.44	.0050	.0000	.6098	1.3
13440	Dec. 5	V. slight.	V. slight.	0.70	4.40	1.70	.0004	.0134	.0112	.0022	.41	.0030	.0000	.6545	1.1

Odor, distinctly vegetable, becoming stronger on heating. —— The first sample was collected from Talbot Millpond, a small millpond on the Rumford River, a short distance below the Norton Reservoir; the last, from the Wading River at the road crossing about 1½ miles above Barrowsville, and just above the point where the river is joined by Chartley Brook.

Microscopical Examination.

No. 13439. Diatomaceæ, *Cyclotella*, 1; *Diatoma*, 1; *Fragilaria*, 3; *Melosira*, 6; *Synedra*, 8. Algæ, *Chlorococcus*, 1. Fungi, *Molds*, 1. Infusoria, *Dinobryon cases*, 56. Miscellaneous, *Zoöglœa*, 64. Total, 141.

No. 13440. Diatomaceæ, *Diatoma*, 1; *Meridion*, 1; *Synedra*, 3; *Tabellaria*, 4. Fungi, *Crenothrix*, 3. Total, 12.

Chemical Examination of Water from Test Wells in Norton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
13050	Oct. 1	Slight, milky.	None.	1.00	9.00	.0064	.0010	.81	.0020	.0000	.0553	3.0	.2550
13051	Oct. 1	Slight, milky.	None.	0.80	8.00	.0016	.0008	.60	.0020	.0000	.0869	3.0	.2600

Odor, very faint or none. —— These samples after standing for one day in the laboratory became decidedly turbid, owing to the oxidation of the large amount of iron in them, and a slight, rusty sediment was deposited. The high color of the water was caused by the presence of the iron oxide, and could be nearly all removed by filtration through filter paper. The colors after filtration were respectively 0.12 and 0.08. The samples were collected from test wells near the factory of A. H. Sweet, and near the road from Norton to Attleborough.

Microscopical Examination.

No organisms.

NORWOOD.

WATER SUPPLY OF NORWOOD.

Chemical Examination of Water from Buckmaster Pond, Dedham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11591	Jan. 3	None.	Slight.	0.05	2.75	0.85	.0094	.0192	.0176	.0016	.34	.0040	.0000	.1950	0.5
11714	Feb. 5	Slight.	Cons.	0.05	2.95	1.20	.0168	.0156	.0134	.0022	.37	.0070	.0000	.2200	0.5
11838	Mar. 5	Slight.	Slight.	0.08	2.85	0.90	.0120	.0150	.0124	.0026	.32	.0070	.0000	.2240	0.5
11990	Apr. 2	Distinct.	Cons., green.	0.15	2.60	0.90	.0010	.0156	.0122	.0034	.33	.0030	.0000	.2117	0.5
12153	May 2	Distinct.	Slight.	0.10	2.65	1.15	.0004	.0158	.0110	.0048	.36	.0050	.0000	.3216	0.3
12312	June 4	Slight.	Slight.	0.20	2.60	1.10	.0006	.0160	.0144	.0016	.32	.0000	.0000	.2733	0.5
12501	July 9	Distinct.	Slight.	0.10	2.60	1.00	.0010	.0200	.0182	.0018	.36	.0050	.0000	.2710	0.4
12681	Aug. 7	Slight.	V. slight.	0.10	3.20	1.50	.0004	.0216	.0186	.0030	.40	.0000	.0000	.2502	0.5
12897	Sept. 5	Slight.	Slight, green.	0.10	3.30	1.45	.0000	.0210	.0156	.0054	.37	.0000	.0001	.2387	0.6
13082	Oct. 4	Slight.	Slight.	0.15	3.00	1.50	.0014	.0210	.0170	.0040	.39	.0000	.0000	.2015	0.5
13260	Nov. 5	Slight.	Slight.	0.08	2.45	1.00	.0080	.0204	.0182	.0022	.41	.0030	.0000	.2387	0.5
13430	Dec. 3	Slight.	Cons.	0.05	2.85	1.05	.0150	.0172	.0152	.0020	.35	.0000	.0000	.2017	0.3
Av	....	....	....	0.10	2.82	1.13	.0055	.0182	.0153	.0029	.36	.0028	.0000	.2373	0.5

Averages by Years.

–	1887*	–	–	0.09	2.64	1.06	.0058	.0212	–	–	.30	.0018	–	–	–
–	1888	–	–	0.15	2.66	0.95	.0069	.0248	–	–	.29	.0065	.0001	–	–
–	1889	–	–	0.11	2.43	0.78	.0025	.0196	.0172	.0024	.30	.0070	.0001	–	–
–	1890	–	–	0.05	2.59	0.99	.0015	.0180	.0147	.0033	.30	.0075	.0000	–	1.0
–	1891	–	–	0.06	2.48	0.97	.0014	.0166	.0140	.0026	.26	.0075	.0000	–	0.7
–	1892	–	–	0.07	2.88	1.24	.0019	.0219	.0172	.0047	.32	.0067	.0000	–	0.7
–	1893	–	–	0.07	2.62	1.08	.0052	.0199	.0156	.0043	.33	.0028	.0000	.2544	0.7
–	1894	–	–	0.10	2.82	1.13	.0055	.0182	.0153	.0029	.36	.0028	.0000	.2373	0.5

* June to December.

NOTE to analyses of 1894: Odor, generally faintly vegetable, sometimes also mouldy or unpleasant; occasionally none. —— The samples were collected from the pond.

NORWOOD.

Microscopical Examination of Water from Buckmaster Pond, Dedham.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . . .	5	6	6	5	3	6	11	9	8	5	7	6
Number of sample, . . .	11591	11714	11838	11990	12153	12312	12501	12681	12897	13082	13260	13430
PLANTS.												
Diatomaceæ, . . .	**10**	**180**	**2,400**	**3,000**	**1,046**	**171**	**1**	**0**	**10**	**2**	**46**	**37**
Asterionella, . . .	5	180	2,400	3,000	880	31	0	0	0	1	0	13
Cyclotella, ...	0	0	0	0	24	84	pr.	0	0	0	44	13
Melosira, ...	0	0	0	0	0	0	0	0	5	0	0	5
Synedra, ...	0	0	0	0	128	32	1	0	1	1	2	4
Tabellaria, ...	5	0	0	0	14	24	0	0	4	0	0	2
Cyanophyceæ, . . .	**2**	**1**	**0**	**0**	**16**	**5**	**4**	**25**	**11**	**0**	**0**	**0**
Anabæna, ...	0	0	0	0	16	4	2	0	1	0	0	0
Chroöcoccus, . . .	0	0	0	0	0	0	0	18	0	0	0	0
Clathrocystis, . . .	0	0	0	0	0	0	0	4	3	0	0	0
Cœlosphærium, . . .	2	1	0	0	0	1	2	0	0	0	0	0
Microcystis, . . .	0	0	0	0	0	0	0	3	7	0	0	0
Algæ, ...	**0**	**2**	**0**	**0**	**11**	**70**	**6**	**10**	**6**	**12**	**15**	**0**
Arthrodesmus, . . .	0	0	0	0	4	0	0	0	0	2	2	0
Botrycoccus, . . .	0	0	0	0	0	0	0	8	1	0	1	0
Protococcus, . . .	0	0	0	0	6	70	0	0	4	0	4	0
Raphidium, . . .	0	2	0	0	0	0	2	2	0	10	8	0
Scenedesmus, . . .	0	0	0	0	1	0	4	0	1	0	0	0
ANIMALS.												
Infusoria, ...	**20**	**16**	**pr.**	**pr.**	**3**	**0**	**pr.**	**1**	**9**	**15**	**178**	**48**
Dinobryon cases, . .	0	0	0	0	3	0	0	0	0	4	176	48
Monas, ...	0	2	0	0	0	0	0	0	0	0	0	0
Peridinium, ...	20	14	pr.	pr.	0	0	pr.	1	7	0	0	0
Trachelomonas, . . .	0	0	0	0	0	0	0	0	2	11	2	0
Vermes, ...	**1**	**pr.**	**0**	**0**	**0**	**2**	**2**	**0**	**0**	**1**	**0**	**0**
Monocerca, ...	1	pr.	0	0	0	2	0	0	0	1	0	0
Polyarthra, ...	0	0	0	0	0	0	2	0	0	0	0	0
Miscellaneous, Zoöglœa, . .	2	0	0	2	0	0	0	9	108	104	0	0
TOTAL, ...	35	199	2,400	3,002	1,076	248	13	45	144	134	239	85

Table showing Heights of Water in Buckmaster Pond on the First of Each Month in 1894.

[Distance below crest of dam.]

DATE. — 1894.	Feet.	DATE. — 1894.	Feet.
Jan. 1, ...	6.25	July 1, ...	1.92
Feb. 1, ...	4.42	Aug. 1, ...	3.33
March 1, ...	2.50	Sept. 1, ...	5.00
April 1, ...	0.75	Oct. 1, ...	5.75
May 1, ...	0.00	Nov. 1, ...	6.33
June 1, ...	0.50	Dec. 1, ...	5.42

ORANGE.

Water Supply of Orange.

Early in the spring of 1894 the water supplied to the town had a disagreeable taste and odor, and upon making a special investigation it was ascertained that the odor was caused by the presence of the organism *Uroglena*, which was found in large numbers in the distributing reservoir. In the main source from which water may be pumped to the distributing reservoir no *Uroglena* was found, but it was subsequently learned that a very small amount of water had been pumped from the Greenhalge Reservoir, a small millpond the water of which is used to furnish power for pumping, which was not examined. After the distributing reservoir had been emptied and refilled the *Uroglena* disappeared. A description of this organism is given in the annual report of the State Board of Health for 1891, pages 645–658, and a statement as to the odor which it imparts to water, and the probable origin of the odor, may be found in the annual report for 1892, pages 370–375.

In connection with the investigation as to the cause of the taste and odor noticed, many examinations were made of water from sources connected with the Orange Water Works, and the results are given in tables which follow.

Chemical Examination of Water from North Pond, Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11906	Mar. 16	Slight.	Slight.	0.30	2.70	1.15	.0004	.0182	.0156	.0026	.11	.0050	.0000	.4480	0.5
12018	Apr. 10	V. slight.	Slight.	0.30	2.80	1.15	.0000	.0164	.0144	.0020	.13	.0050	.0000	.3697	0.6
12372	June 13	Distinct, green.	Slight.	0.50	3.10	1.55	.0004	.0312	.0262	.0050	.14	.0000	.0000	.5613	0.9
12542	July 16	Distinct.	Slight.	0.65	3.65	1.90	.0000	.0274	.0236	.0038	.14	.0000	.0002	.6730	1.1
12764	Aug. 15	Distinct, green.	Slight.	0.70	3.75	2.00	.0000	.0250	.0198	.0052	.11	.0000	.0000	.6699	1.0
12977	Sept. 18	V. slight.	Slight.	0.75	3.95	1.75	.0002	.0218	.0200	.0018	.15	.0000	.0000	.5929	1.1
13159	Oct. 17	Distinct.	Cons., brown.	0.80	3.35	1.65	.0000	.0278	.0206	.0072	.12	.0020	.0000	.6091	1.1
13359	Nov. 21	Slight.	Slight, brown.	0.90	3.30	1.70	.0054	.0218	.0198	.0020	.10	.0000	.0000	.6240	0.9
13527	Dec. 19	V. slight.	Slight.	1.10	3.80	1.80	.0042	.0166	.0150	.0016	.13	.0050	.0000	.8200	0.5
Av.	....	....	....	0.67	3.38	1.63	.0012	.0229	.0194	.0035	.13	.0019	.0000	.5964	0.9

Odor, generally vegetable, sometimes also mouldy, becoming stronger on heating. —— The samples were collected from the pond.

ORANGE.

Microscopical Examination of Water from North Pond, Orange.

[Number of organisms per cubic centimeter.]

	1894.								
	Mar.	April.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	17	11	14	17	16	19	18	22	21
Number of sample,	11906	12018	12372	12542	12764	12977	13159	13359	13527
PLANTS.									
Diatomaceæ,	93	505	348	313	260	200	51	399	10
Asterionella,	88	480	20	0	0	0	12	212	4
Cyclotella,	2	3	48	1	0	0	1	1	0
Melosira,	2	5	0	0	0	16	25	44	0
Pinnularia,	0	pr.	0	0	0	0	2	2	0
Synedra,	1	16	0	0	0	0	2	4	0
Tabellaria,	pr.	1	280	312	260	184	9	136	6
Cyanophyceæ,	0	0	0	9	9	2	1	0	0
Clathrocystis,	0	0	0	2	9	2	0	0	0
Cœlosphærium,	0	0	0	7	0	0	1	0	0
Algæ,	pr.	0	2	289	77	200	3	54	0
Arthrodesmus,	0	0	2	1	1	0	0	1	0
Chlorococcus,	0	0	0	4	0	200	0	0	0
Closterium,	pr.	0	0	0.	48	0	0	52	0
Protococcus,	0	0	0	272	5	0	0	0	0
Raphidium,	0	0	0	0	14	0	0	0	0
Scenedesmus,	0	0	0	0	2	0	3	0	0
Staurastrum,	0	0	0	12	7	0	0	1	0
Fungi, Crenothrix,	0	5	4	0	0	0	0	0	2
ANIMALS.									
Rhizopoda, Actinophrys,	0	0	0	0	0	2	0	0	0
Infusoria,	14	37	60	16	64	7	1	0	1
Ceratium,	0	0	0	0	0	2	0	0	0
Dinobryon,	2	5	0	0	0	0	0	0	0
Dinobryon cases,	10	32	0	0	10	1	0	0	0
Epistylis,	0	0	0	10	0	0	0	0	0
Mallomonas,	0	pr.	60	0	1	0	1	0	0
Peridinium,	pr.	pr.	0	4	48	4	0	0	1
Synura,	2	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	2	5	0	0	0	0
Vermes, Polyarthra,	0	0	0	1	0	0	0	1	0
Miscellaneous, Zoöglœa,	0	16	0	0	56	28	244	0	0
TOTAL,	107	563	414	628	466	439	300	454	13

ORANGE.

Chemical Examination of Water from Coolidge Brook Reservoir, Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11935	Mar. 22	V. slight.	Slight.	0.30	2.05	0.70	.0010	.0142	.0120	.0022	.10	.0050	.0000	.3579	0.2
12019	Apr. 10	None.	Slight.	0.23	2.40	0.75	.0000	.0090	.0066	.0024	.14	.0050	.0000	.3160	0.5
12373	June 13	V. slight.	Slight.	0.43	1.90	1.15	.0000	.0148	.0128	.0020	.14	.0030	.0001	.4474	0.8
Av.	....	....	....	0.32	2.12	0.87	.0003	.0127	.0105	.0022	.16	.0043	.0000	.3738	0.5

Odor, vegetable.—— The samples were collected from the reservoir.

Microscopical Examination of Water from Coolidge Brook Reservoir, Orange.

[Number of organisms per cubic centimeter.]

	1894. March.	1894. April.	1894. June.
Day of examination,	23	11	16
Number of sample,	11935	12019	12373
PLANTS.			
Diatomaceæ,	pr.	5	923
Cyclotella,	0	0	3
Diatoma,	pr.	1	0
Meridion,	0	2	0
Synedra,	pr.	pr.	920
Tabellaria,	0	2	0
ANIMALS.			
Infusoria,	pr.	0	7
Monas,	0	0	1
Peridinium,	pr.	0	6
Vermes,	0	0	2
Polyarthra,	0	0	1
Rotifer,	0	0	1
Miscellaneous, Zoöglœa,	1	0	10
TOTAL,	1	5	942

ORANGE.

Chemical Examination of Water from the Distributing Reservoir of the Orange Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11936	Mar. 22	Slight.	Slight, white.	0.22	2.45	1.05	.0010	.0128	.0098	.0030	.09	.0050	.0000	.3436	0.2
11987	Apr. 2	Slight.	Slight.	0.18	2.60	0.65	.0006	.0094	.0072	.0022	.11	.0030	.0000	.2903	0.3
12020	Apr. 10	V. slight.	Slight.	0.20	2.65	0.70	.0002	.0086	.0072	.0014	.14	.0030	.0000	.2781	0.3
12121	Apr. 30	V. slight.	Cons., sandy.	0.28	2.10	0.65	.0000	.0126	.0096	.0030	.16	.0030	.0000	.0987	0.6
12374	June 13	Slight.	Slight.	0.40	3.30	1.20	.0018	.0184	.0166	.0018	.28	.0000	.0001	.4543	0.8
12543	July 16	Slight.	V. slight.	0.20	4.25	1.50	.0006	.0114	.0096	.0018	.11	.0000	.0004	.3303	0.9
12765	Aug. 15	Distinct.	Slight.	1.40	5.00	2.65	.0018	.0346	.0302	.0044	.11	.0030	.0000	1.0395	0.9
12978	Sept. 18	Slight.	Slight.	0.85	4.75	2.50	.0004	.0288	.0240	.0048	.13	.0020	.0001	.7469	1.3
13160	Oct. 17	Slight.	Slight.	0.50	3.90	1.75	.0000	.0150	.0140	.0010	.14	.0020	.0000	.5451	1.1
13360	Nov. 21	V. slight.	V. slight.	0.53	3.75	1.65	.0006	.0122	.0100	.0022	.13	.0070	.0000	.5226	0.9
13528	Dec. 19	V. slight.	Slight.	0.38	3.25	1.25	.0000	.0106	.0090	.0016	.16	.0030	.0000	.4173	1.1
Av.*	....	....	....	0.52	3.68	1.58	.0007	.0171	.0146	.0025	.14	.0028	.0001	.5136	0.8

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor of No. 11936, very faintly aromatic; of Nos. 11987, 12374, 12765, 12978 and 13360, vegetable; of No. 12020, distinctly disagreeable and fishy; of the remaining samples, none. On heating, the odor of the first four samples was decidedly oily.——The samples were collected from the reservoir.

ORANGE.

Microscopical Examination of Water from the Distributing Reservoir of the Orange Water Works.

[Number of organisms per cubic centimeter.]

	1894.										
	Mar.	Apr.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	23	4	11	1	16	17	16	19	18	22	21
Number of sample,	11936	11987	12020	12121	12374	12543	12765	12978	13160	13360	13528
PLANTS.											
Diatomaceæ,	**9**	**28**	**9**	**28**	**57**	**24**	**156**	**71**	**0**	**0**	**5**
Asterionella,	0	0	0	0	0	0	0	47	0	0	5
Cyclotella,	1	0	0	0	0	1	0	6	0	0	0
Melosira,	8	21	3	0	0	0	0	0	0	0	0
Synedra,	pr.	2	5	28	56	12	36	1	0	0	0
Tabellaria,	0	5	1	0	1	11	120	17	0	0	0
Algæ,	**1**	**0**	**0**	**0**	**10**	**4**	**48**	**13**	**0**	**0**	**0**
Chlorococcus,	1	0	0	0	0	0	0	7	0	0	0
Closterium,	0	0	0	0	0	0	48	0	0	0	0
Protococcus,	0	0	0	0	10	0	0	0	0	0	0
Raphidium,	0	0	0	0	0	4	0	6	0	0	0
Fungi, Crenothrix,	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**8**	**0**	**0**	**0**
ANIMALS.											
Infusoria,	**533**	**416**	**390**	**234**	**11**	**0**	**37**	**197**	**0**	**0**	**0**
Dinobryon,	43	19	34	0	0	0	3	0	0	0	0
Dinobryon cases,	290	96	106	34	9	0	30	192	0	0	0
Monas,	0	0	0	0	0	0	0	3	0	0	0
Peridinium,	0	1	pr.	0	2	0	4	2	0	0	0
Uroglena,	200	300	250	200	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	**4**	**0**	**0**	**0**	**0**	**0**	**52**	**0**	**0**	**0**	**4**
TOTAL,	547	444	399	262	78	28	298	289	0	0	9

ORANGE.

Chemical Examination of Water from a Faucet in Orange supplied from the Orange Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11937	Mar. 22	Slight.	Slight.	0.25	2.50	0.90	.0008	.0068	.0064	.0004	.10	.0030	.0000	.3476	0.5
11988	Apr. 2	V. slight.	V. slight.	0.18	2.80	1.00	.0018	.0080	.0066	.0014	.11	.0050	.0000	.2872	0.3
12021	Apr. 10	V. slight.	V. slight.	0.22	2.35	1.00	.0002	.0070	.0056	.0014	.14	.0000	.0000	.2804	0.2
12122	Apr. 30	None.	V. slight.	0.28	2.90	1.00	.0000	.0080	.0062	.0018	.13	.0030	.0000	.3026	0.6
Av.	....	....	....	0.23	2.64	0.97	.0007	.0074	.0062	.0012	.12	.0027	.0000	.3044	0.4

Odor of the first sample, decided; of the second, distinctly oily; of the third, decidedly disagreeable and fishy, becoming oily on heating; of the fourth, distinctly vegetable and grassy. —— The samples were collected from a faucet in the town.

Microscopical Examination of Water from a Faucet in Orange supplied from the Orange Water Works.

[Number of organisms per cubic centimeter.]

	1894.			
	March.	April.	April.	May.
Day of examination,	23	4	11	1
Number of sample,	11937	11988	12021	12122
PLANTS.				
Diatomaceæ,	3	7	0	20
Fragilaria,	0	5	0	0
Synedra,	1	2	0	20
Tabellaria,	2	0	0	pr.
Fungi, Crenothrix,	2	0	0	pr.
ANIMALS.				
Infusoria,	41	73	89	6
Dinobryon,	2	1	0	0
Dinobryon cases,	39	70	86	6
Peridinium,	0	1	0	pr.
Uroglena sporocysts,	0	1	3	0
Miscellaneous, Zoöglœa,	0	2	0	13
TOTAL,	46	82	89	39

PALMER.

Water Supply of Palmer Fire District, Palmer. — Palmer Water Company.

Chemical Examination of Water from a Faucet in Palmer.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
12379	1894. June 15	Distinct.	Cons., brown.	0.28	3.50	1.15	.0004	.0092	.0064	.0028	.11	.0000	.0000	.2156	1.1

Odor, distinctly vegetable.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 6; *Melosira*, 7; *Navicula*, 1; *Surirella*, 1; *Synedra*, 5; *Tabellaria*, 6. Infusoria, *Dinobryon cases*, 4. Miscellaneous, *Zoöglœa*, 56. Total, 86.

Water Supply of Peabody.

Chemical Examination of Water from Brown's Pond, Peabody.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
12919	1894. Sept. 10	Distinct.	Slight.	0.18	2.95	1.20	.0018	.0164	.0154	.0010	.53	.0030	.0000	.2695	0.6

Odor, faintly vegetable. —— The sample was collected from the pond.

Microscopical Examination.

Cyanophyceæ, *Aphanocapsa*, 2. Algæ, *Arthrodesmus*, 1; *Cosmarium*, 1. Infusoria, *Peridinium*, 5; *Trachelomonas*, 2. Miscellaneous, *Zoöglœa*, 80. Total, 91.

PEABODY.

Chemical Examination of Water from Spring Pond, Peabody.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12918	Sept. 10	Distinct.	Slight, earthy.	0.02	3.60	0.45	.0010	.0126	.0100	.0026	.64	.0020	.0000	.0924	1.4

Odor, faintly vegetable. —— The sample was collected from the pond.

Microscopical Examination.

Diatomaceæ, *Pinnularia*, 1; *Synedra*, 5; *Tabellaria*, 4. Cyanophyceæ, *Anabæna*, 12. Algæ, *Ulothrix*, 2. Infusoria, *Peridinium*, 12. Miscellaneous, *Zoöglœa*, 44. Total, 80.

Pepperell.

Chemical Examination of Water from Various Sources collected in Connection with an Investigation for a Water Supply for Pepperell.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13173	Oct. 19	Slight.	Slight.	0.07	2.25	0.95	.0004	.0198	.0180	.0018	.16	.0100	.0000	.3634	0.2
13321	Nov. 16	None.	V. slight.	0.30	8.65	2.00	.0000	.0090	.0074	.0016	.31	.0280	.0000	.3432	4.3
13377	Nov. 26	None.	V. slight.	0.65	4.60	1.75	.0010	.0154	.0136	.0018	.20	.0020	.0000	.7093	1.8
13378	Nov. 26	V. slight.	V. slight.	0.60	5.45	1.60	.0000	.0152	.0128	.0024	.20	.0130	.0000	.5822	2.2
13379	Nov. 26	None.	Slight.	0.30	5.80	1.40	.0002	.0090	.0080	.0010	.28	.0450	.0000	.3075	2.6
13408	Dec. 1	Slight.	Slight.	0.30	3.75	1.20	.0008	.0212	.0190	.0022	.17	.0030	.0000	.4851	2.1
13409	Dec. 2	V. slight.	V. slight.	0.50	3.95	1.55	.0000	.0120	.0108	.0012	.17	.0030	.0001	.5467	1.4

Odor of Nos. 13377, 13408 and 13409, vegetable; of the other samples, none. —— The samples were collected as follows: No. 13173 from Rock Pond in Hollis, New Hampshire, near the surface; No. 13321 from Sucker Brook at Oak Hill Street, Pepperell; No. 13377 from Smith and Willoughby's Pond on Gulf Brook; No. 13378 from Unquetenassett Brook at street between Boston and Maine Railroad and Nashua River in Dunstable; No. 13379 from Reedy Meadow Brook at Leighton Street; No. 13408 from Heald's Pond; No. 13409 from Nissitissitt River at North Village.

PEPPERELL.

Microscopical Examination of Water from Various Sources collected during an Investigation for a Water Supply for Pepperell.

[Number of organisms per cubic centimeter.]

	1894.						
	Oct.	Nov.	Nov.	Nov.	Nov.	Dec.	Dec.
Day of examination,	22	20	27	27	27	3	3
Number of sample,	13173	13321	13377	13378	13379	13408	13409
PLANTS.							
Diatomaceæ,	**33**	**0**	**1**	**6**	**7**	**24**	**0**
Cyclotella,	32	0	0	0	0	0	0
Fragilaria,	0	0	0	2	0	0	0
Grammatophora,	0	0	0	1	0	0	0
Odontidium,	1	0	0	0	0	0	0
Synedra,	0	0	1	1	7	24	0
Tabellaria,	0	0	0	2	0	0	0
Cyanophyceæ, Anabæna,	**9**	**0**	**0**	**0**	**0**	**0**	**0**
Algæ,	**44**	**0**	**0**	**0**	**0**	**0**	**0**
Protococcus,	43	0	0	0	0	0	0
Staurastrum,	1	0	0	0	0	0	0
Fungi, Crenothrix,	**0**	**6**	**1**	**0**	**0**	**0**	**0**
ANIMALS.							
Rhizopoda, Difflugia,	**2**	**0**	**0**	**0**	**0**	**0**	**0**
Infusoria,	**6**	**0**	**9**	**0**	pr.	**50**	**1**
Dinobryon,	0	0	2	0	0	1	0
Dinobryon cases,	5	0	7	0	0	36	1
Peridinium,	1	0	0	0	0	0	0
Synura,	0	0	0	0	pr.	13	0
Vermes, Anurea,	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous, Zoöglœa,	**112**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL,	207	6	11	6	7	74	1

PEPPERELL.

Chemical Examination of Water from a Test Well and a Spring in Pepperell.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
13174	Oct. 19	None.	Slight.	0.03	8.60	.0000	.0010	.27	.0000	.0000	.0154	5.3	.0150
13376	Nov. 26	None.	V. slight.	0.02	6.00	.0004	.0016	.32	.0200	.0000	.0590	3.8	.0100

Odor, none. —— The first sample was collected from a 2½-inch tubular test well 25.8 feet in depth, located about 200 feet west of Sucker Brook and 300 feet north of Sartelle Street; the last sample from Sartelle's Spring, about 100 feet west of Sucker Brook and north of Sartelle Street.

Microscopical Examination.

No. 13174. No organisms.
No. 13376. Diatomaceæ, *Tabellaria*, 1. Algæ, *Conferva*, 1. Fungi, *Crenothrix*, 2. Total, 4.

PITTSFIELD.

Chemical Examination of Water from a Well and a Spring of the Pontoosuc Woolen Company, Pittsfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12830	Aug. 27	V. slight.	Slight.	0.02	27.70	.0006	.0020	0.15	.1000	.0001	.0154	25.8	.0110
12831	Aug. 27	None.	V. slight.	0.02	49.20	.0000	.0032	1.84	.7500	.0001	.0231	34.6	.0130

Odor of the first sample, decidedly disagreeable; of the second, none. —— The first sample was collected from the well; the last from the spring.

Microscopical Examination.

No. 12830. Fungi, *Crenothrix*, 8; *Molds*, 1. Total, 9.
No. 12831. No organisms.

PLYMOUTH.

Water Supply of Plymouth.

Chemical Examination of Water from Little South Pond, Plymouth.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11670	Jan. 22	V. slight.	Cons.	0.03	2.20	0.55	.0000	.0082	.0074	.0008	.64	.0000	.0000	.1090	0.3
11852	Mar. 6	V. slight.	Slight, earthy.	0.00	1.85	0.50	.0014	.0126	.0112	.0014	.58	.0030	.0000	.0944	0.2
11996	Apr. 3	V. slight.	Slight, white.	0.01	2.30	0.60	.0000	.0134	.0116	.0018	.61	.0030	.0000	.0639	0.0
12146	May 1	None.	Slight, white.	0.02	3.25	0.80	.0014	.0122	.0100	.0022	.68	.0000	.0000	.1216	0.0
12352	June 11	V. slight.	Slight.	0.05	4.95	1.35	.0004	.0152	.0120	.0032	.63	.0000	.0000	.1294	0.5
12559	July 16	Slight.	Slight.	0.02	3.25	1.10	.0034	.0112	.0090	.0022	.70	.0000	.0000	.1987	0.2
12991	Sept. 19	Slight.	Slight.	0.08	2.70	1.20	.0006	.0160	.0136	.0024	.70	.0000	.0000	.1039	0.3
13459	Dec. 10	Slight.	V. slight.	0.02	2.60	0.55	.0006	.0212	.0162	.0050	.70	.0000	.0000	.1001	0.0
Av.	....	....	....	0.03	2.89	0.83	.0010	.0138	.0114	.0024	.66	.0008	.0000	.1151	0.2

Odor of No. 11670, none, becoming vegetable and grassy the next day; of No. 11852, vegetable; of No. 11996, very faintly vegetable and somewhat oily; of No. 12146, none; of No. 12352, decidedly disagreeable; of No. 12559, distinctly grassy and mouldy; of No. 12991, faintly vegetable and grassy; of No. 13459, distinctly oily. —— The samples were collected from the pond.

Microscopical Examination of Water from Little South Pond, Plymouth.

[Number of organisms per cubic centimeter.]

	1894.							
	Jan.	Mar.	Apr.	May.	June.	July.	Sept.	Dec.
Day of examination, ...	24	7	5	3	13	18	20	11
Number of sample, ...	11670	11852	11996	12146	12352	12559	12991	13459
PLANTS.								
Diatomaceæ, ...	13	pr.	30	17	64	pr.	3	0
Asterionella, ...	13	0	6	4	38	0	0	0
Synedra, ...	0	pr.	20	3	26	pr.	2	0
Tabellaria, ...	0	0	4	10	0	0	1	0
Cyanophyceæ, Anabæna, .	0	0	1	0	3	21	17	0
Algæ, ...	0	0	10	1	0	5	2	0
Protococcus, ...	0	0	10	0	0	0	0	0
Raphidium, ...	0	0	0	1	0	5	2	0

PLYMOUTH.

Microscopical Examination of Water from Little South Pond, Plymouth—Concluded.

[Number of organisms per cubic centimeter.]

	1894.							
	Jan.	Mar.	Apr.	May.	June.	July.	Sept.	Dec.
ANIMALS.								
Infusoria,	268	3	615	5	0	0	0	53
Dinobryon,	266	0	400	0	0	0	0	10
Dinobryon cases,	0	2	210	5	0	0	0	18
Monas,	1	0	0	0	0	0	0	0
Peridinium,	1	1	4	0	0	0	0	0
Stentor,	0	0	1	0	0	0	0	0
Uroglena,	0	0	0	0	0	0	0	25
Vermes, Monocerca,	0	0	0	1	0	0	0	0
Miscellaneous, Zoöglœa,	0	3	0	2	12	34	36	0
TOTAL,	281	6	656	26	79	60	58	53

Chemical Examination of Water from Faucets in Plymouth, supplied from the Plymouth Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13452	Dec. 6	V. slight.	Slight.	0.00	2.65	0.75	.0006	.0144	.0124	.0020	.67	.0000	.0000	.1078	0.5
13460	Dec. 10	V. slight.	V. slight.	0.02	2.55	0.65	.0000	.0168	.0152	.0016	.68	.0000	.0000	.1116	0.3

Odor, decidedly oily, becoming stronger on heating. —— The first sample was collected at the Town Hall, and the last from a faucet on Howland Street.

Microscopical Examination.

No. 13452. Diatomaceæ, *Asterionella*, 16; *Synedra*, 4; *Tabellaria*, 10. Infusoria, *Dinobryon cases*, 20. Total, 50.

No. 13460. Diatomaceæ, *Asterionella*, 9; *Melosira*, 2; *Meridion*, 1; *Synedra*, 7. Infusoria, *Dinobryon*, 1; *Dinobryon cases*, 11. Total, 31.

Chemical Examination of Water from Cold Spring, Plymouth.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1894.												
12603	July 24	None.	None.	0.0	3.90	.0000	.0000	.84	.0250	.0000	.0000	0.6	.0140
13453	Dec. 6	None.	V. slight.	0.0	3.90	.0004	.0012	.85	.0250	.0000	.0192	0.3	.0000

Odor, none. —— The samples were collected from Cold Spring, so called, in Court Street.

Microscopical Examination.

No organisms.

PROVINCETOWN.

WATER SUPPLY OF PROVINCETOWN.

Chemical Examination of Water from the Tubular Wells of the Provincetown Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11622	Jan. 9	Distinct, milky.	Cons., yellow.	0.65	7.20	.0010	.0042	1.99	.0020	.0001	.5109	2.9	.1200
11722	Feb. 6	Decided, milky.	Cons., rusty.	0.70	7.00	.0036	.0090	2.01	.0000	.0001	.5856	0.9	.0900
11857	Mar. 6	Decided, floc.	Heavy, floc.	0.75	7.60	.0032	.0080	2.00	.0030	.0000	.6440	1.8	.1750
12027	Apr. 10	Decided, reddish.	Cons., rusty.	0.60	7.40	.0012	.0066	2.03	.0100	.0000	.6383	1.9	.1300
12176	May 8	Distinct, milky.	Slight.	0.65	7.00	.0012	.0062	2.16	.0030	.0000	.6109	1.3	.0950
12365	June 12	Decided, floc.	Slight, rusty.	1.20	8.70	.0048	.0086	2.24	.0000	.0000	.7623	1.7	.2340
12540	July 16	Distinct, milky.	Cons., rusty.	1.60	9.20	.0044	.0108	2.21	.0050	.0001	.7631	1.8	.3100
12756	Aug. 14	Decided, milky.	Cons., rusty.	1.45	7.90	.0056	.0116	2.20	.0100	.0001	.7638	1.8	.2500
12913	Sept. 10	Decided, milky.	Cons., rusty.	1.50	8.60	.0054	.0082	2.20	.0030	.0001	.7007	1.3	.2400
13114	Oct. 9	Decided, milky.	Cons., rusty.	1.60	8.60	.0078	.0102	2.26	.0030	.0000	.7767	1.6	.3600
13278	Nov. 8	Decided, rusty.	Cons., rusty.	1.20	8.00	.0066	.0112	2.62	.0030	.0000	.7546	1.7	.4300
13552	Dec. 26	Decided, milky.	Slight, rusty.	1.10	7.70	.0072	.0128	2.35	.0050	.0000	.7430	1.9	.2200
Av.	....	....	....	1.09	7.91	.0043	.0090	2.19	.0039	.0000	.6878	1.7	.2212

Odor, generally vegetable or none. —— The samples were collected from a faucet at the pumping station.

Extended references as to the character of this water, which differs from other ground waters in the State, may be found in the annual report for 1892, pages 41-44 and 214-218.

Microscopical Examination of Water from the Tubular Wells of the Provincetown Water Works.

[Number of organisms per cubic centimeter.]

	1894. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . . .	11	8	8	13	11	14	17	16	12	11	9	27
Number of sample, . . .	11622	11722	11857	12027	12176	12365	12540	12756	12913	13114	13278	13552
PLANTS.												
Fungi, Crenothrix, . .	6	31,600	780	2,120	76	2	72	1,600	280	920	20	92
Miscellaneous, Zoöglœa, .	0	76	108	412	0	0	0	0	0	0	0	0
TOTAL, ...	6	31,676	888	2,532	76	2	72	1,600	280	920	20	92

PROVINCETOWN.

Chemical Examination of Water from Faucets in Provincetown.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12028	Apr. 10	Decided, rusty.	Cons., rusty.	0.75	7.00	.0002	.0082	2.03	.0070	.0001	.6201	1.7	.1100
12177	May 8	Distinct, milky.	V. slight.	0.90	7.20	.0000	.0080	2.21	.0030	.0000	.5904	1.3	.1050
12366	June 12	Distinct, milky.	Slight.	1.00	8.80	.0000	.0100	2.41	.0000	.0000	.6198	1.6	.2000
12541	July 16	Decided, rusty.	Cons., rusty.	1.80	8.10	.0054	.0114	2.25	.0050	.0003	.7792	1.6	.3900
12757	Aug. 14	Decided, milky.	Slight, rusty.	1.30	7.90	.0000	.0120	2.20	.0030	.0004	.6083	1.6	.1500
12914	Sept. 10	Decided, milky.	Slight, rusty.	1.30	8.90	.0038	.0080	2.19	.0000	.0003	.6314	2.1	.2000
13115	Oct. 9	Decided, milky.	Slight.	1.40	8.60	.0066	.0086	2.24	.0000	.0001	.6825	1.6	.2500
13279	Nov. 8	Decided, rusty.	Slight.	1.40	7.80	.0032	.0092	2.36	.0030	.0000	.7084	1.7	.2500
13449	Dec. 5	Decided, rusty.	Heavy, rusty.	0.90	8.10	.0068	.0100	2.20	.0030	.0000	.7392	1.6	.3200
13450	Dec. 6	Decided, rusty.	Cons., rusty.	1.00	7.70	.0064	.0102	2.20	.0000	.0000	.7415	1.6	.3400
Av.	....	....	....	1.20	8.02	.0029	.0095	2.23	.0025	.0001	.6645	1.6	.2206

Odor, generally vegetable or none. —— The samples were collected from faucets in the town, and represent water that has passed through the tank.

Microscopical Examination of Water from Faucets in Provincetown.

[Number of organisms per cubic centimeter.]

	1894.									
	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Dec.
Day of examination,	13	11	14	17	16	12	11	9	7	7
Number of sample,	12028	12177	12366	12541	12757	12914	13115	13279	13449	13450
PLANTS.										
Fungi, Crenothrix,	1,720	308	22	72	1,200	96	1,040	40	1,360	300
ANIMALS.										
Infusoria, Trachelomonas,	0	0	0	0	0	0	4	0	0	0
Total,	1,720	308	22	72	1,200	96	1,044	40	1,360	300

QUINCY.

Water Supply of Quincy.

The advice of the State Board of Health to the city of Quincy, relative to a proposed increase of the water supply of the city, may be found on pages 38–41 of this volume. Analyses of samples of water collected in connection with the investigation for an additional supply are given in the tables on pages 294–296.

Chemical Examination of Water from Town Brook just above the Storage Reservoir of the Quincy Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11682	Jan. 24	V. slight.	Slight.	0.60	3.75	1.35	.0000	.0102	.0082	.0020	.60	.0050	.0000	.4827	0.6
11809	Feb. 26	V. slight.	Slight.	0.50	3.80	1.25	.0000	.0110	.0084	.0026	.65	.0050	.0000	.4720	0.3
11946	Mar. 26	V. slight.	Slight.	0.80	3.30	1.35	.0000	.0142	.0128	.0014	.58	.0030	.0000	.6545	0.3
12096	Apr. 23	V. slight.	Cons.	1.25	3.25	1.45	.0006	.0196	.0174	.0022	.61	.0000	.0000	.8137	0.5
12266	May 21	V. slight.	Cons.	1.80	4.95	2.55	.0006	.0226	.0216	.0010	.54	.0030	.0000	1.0413	0.6
12431	June 25	Slight.	Slight, brown.	1.20	4.70	1.25	.0012	.0158	.0140	.0018	.54	.0050	.0002	.5621	0.6
12599	July 24	Slight.	Cons.	0.75	4.30	1.55	.0000	.0154	.0130	.0024	.55	.0050	.0001	.5144	0.8
12795	Aug. 21	Decided.	Cons., rusty.	0.55	4.10	2.00	.0000	.0248	.0170	.0078	.72	.0000	.0000	.4774	0.7
13026	Sept. 25	V. slight.	Slight.	1.00	5.40	1.65	.0000	.0150	.0130	.0020	.68	.0000	.0000	.6083	0.8
13194	Oct. 23	V. slight.	V. slight.	1.20	5.30	1.90	.0002	.0164	.0150	.0014	.68	.0000	.0000	.7781	0.9
13382	Nov. 27	V. slight.	V. slight.	0.73	4.60	1.65	.0006	.0136	.0104	.0032	.69	.0020	.0000	.7478	0.8
13544	Dec. 26	V. slight.	Slight.	0.60	4.25	1.50	.0004	.0114	.0098	.0016	.72	.0080	.0000	.5020	0.6
Av.	....	....	....	0.92	4.31	1.62	.0003	.0158	.0134	.0024	.63	.0030	.0000	.6379	0.6

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dis-solved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
–	1887*	–	–	0.50	5.80	1.50	.0000	.0133	–	–	.65	.0080	–	–	–
–	1888†	–	–	0.45	3.64	1.05	.0001	.0122	–	–	.54	.0070	.0003	–	–
–	1889	–	–	1.21	4.61	1.87	.0013	.0239	.0203	.0036	.48	.0073	.0001	–	–
–	1890	–	–	0.73	5.22	2.17	.0024	.0187	.0155	.0032	.52	.0125	.0002	–	1.3
–	1891	–	–	0.72	4.22	1.50	.0004	.0156	.0132	.0024	.49	.0112	.0001	–	0.7
–	1892	–	–	0.87	4.57	1.56	.0041	.0191	.0159	.0032	.55	.0114	.0001	–	0.8
–	1893	–	–	0.93	4.53	1.81	.0014	.0168	.0140	.0028	.57	.0110	.0001	.7298	0.8
–	1894	–	–	0.92	4.31	1.62	.0003	.0158	.0134	.0024	.63	.0030	.0000	.6379	0.6

* October. † November and December.

Note to analyses of 1894: Odor, generally distinctly vegetable. —— The samples were collected from the brook, above the reservoir.

QUINCY.

Microscopical Examination of Water from Town Brook just above the Storage Reservoir of the Quincy Water Works.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	26	27	28	25	23	27	25	22	25	24	28	27
Number of sample,	11682	11809	11946	12096	12266	12431	12599	12795	13026	13194	13382	13544
PLANTS.												
Diatomaceæ,	24	3	22	43	19	1	0	71	0	0	0	3
Asterionella,	0	0	0	0	0	0	0	7	0	0	0	0
Meridion,	24	2	2	1	0	0	0	0	0	0	0	3
Synedra,	0	1	18	34	10	1	0	64	0	0	0	0
Tabellaria,	0	0	2	8	9	0	0	0	0	0	0	0
Algæ, Desmidium,	0	0	0	0	7	0	0	0	0	0	0	0
Fungi, Crenothrix,	1	0	0	0	0	5	44	4	2	5	1	2
ANIMALS.												
Infusoria,	0	0	1	pr.	0	0	1	184	0	0	0	3
Dinobryon,	0	0	0	0	0	0	0	0	0	0	0	3
Monas,	0	0	0	0	0	0	0	3	0	0	0	0
Peridinium,	0	0	1	pr.	0	0	0	180	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	1	1	0	0	0	0
Miscellaneous, Zoöglœa,	2	0	0	0	0	52	40	920	16	5	0	0
TOTAL,	27	3	23	43	26	58	85	1,179	18	10	1	8

QUINCY.

Chemical Examination of Water from the Storage Reservoir, Quincy.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11683	Jan. 24	V. slight.	V. slight.	0.55	4.00	1.35	.0000	.0128	.0090	.0038	.65	.0070	.0000	.5032	0.8
11810	Feb. 26	V. slight.	Slight.	0.40	3.30	1.00	.0008	.0116	.0104	.0012	.56	.0070	.0000	.4320	0.2
11947	Mar. 26	Distinct.	Slight.	0.53	3.40	1.05	.0028	.0164	.0132	.0032	.65	.0070	.0000	.4042	0.4
12097	Apr. 23	Slight.	Cons.	0.38	3.15	1.35	.0010	.0150	.0110	.0040	.66	.0180	.0000	.4211	0.5
12267	May 21	Distinct.	Cons.	0.60	3.45	1.60	.0014	.0228	.0164	.0064	.60	.0030	.0000	.4883	0.8
12432	June 25	Distinct.	Cons., yellow.	0.60	4.15	1.65	.0000	.0270	.0200	.0070	.67	.0000	.0000	.5375	0.6
12600	July 24	Decided, green.	Cons., green.	0.60	4.15	1.90	.0000	.0274	.0176	.0098	.73	.0040	.0000	.5182	0.8
12794	Aug. 21	Slight.	Slight.	1.40	7.85	4.00	.0006	.0322	.0298	.0024	.67	.0000	.0000	1.5400	1.6
13027	Sept. 25	Distinct.	Cons.	0.70	4.20	1.80	.0024	.0288	.0180	.0108	.66	.0020	.0000	.4990	0.8
13195	Oct. 23	Decided.	Cons.	0.90	4.70	2.00	.0126	.0356	.0232	.0124	.71	.0030	.0000	.5949	0.9
13383	Nov. 27	Distinct, milky.	Cons., rusty.	0.70	4.60	1.50	.0022	.0244	.0168	.0076	.75	.0050	.0000	.6929	0.8
13546	Dec. 26	Slight.	Slight.	0.65	4.20	1.35	.0004	.0206	.0152	.0054	.74	.0080	.0000	.5313	0.8
Av.	....	....	....	0.67	4.26	1.71	.0020	.0229	.0167	.0062	.67	.0053	.0000	.5969	0.8

Averages by Years.

–	1888*	–	–	0.50	3.95	1.13	.0030	.0178	.0132	.0046	.68	.0150	.0003	–	–
–	1889	–	–	0.92	3.76	1.19	.0116	.0303	.0238	.0065	.53	.0087	.0003	–	–
–	1890	–	–	0.70	4.56	1.76	.0085	.0249	.0178	.0071	.54	.0166	.0002	–	1.3
–	1891	–	–	0.70	3.97	1.60	.0027	.0274	.0178	.0096	.50	.0100	.0000	–	0.7
–	1892	–	–	0.62	4.07	1.41	.0051	.0237	.0175	.0062	.61	.0098	.0001	–	0.9
–	1893	–	–	0.56	3.81	1.51	.0052	.0218	.0172	.0046	.61	.0104	.0001	.5052	0.8
–	1894	–	–	0.67	4.26	1.71	.0020	.0229	.0167	.0062	.67	.0053	.0000	.5969	0.8

* November and December.

NOTE to analyses of 1894: Odor, vegetable, and occasionally unpleasant. —— The samples were collected from the reservoir.

QUINCY.

Microscopical Examination of Water from the Storage Reservoir, Quincy.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	26	27	29	25	23	28	25	22	26	24	28	27
Number of sample,	11683	11810	11947	12097	12267	12432	12600	12794	13027	13195	13383	13545
PLANTS.												
Diatomaceæ,	50	25	200	29	1,080	1,413	6,040	1	12	125	4	0
Asterionella,	0	0	0	5	800	4	0	0	0	96	0	0
Cyclotella,	0	0	76	0	0	2	0	0	0	0	0	0
Diatoma,	0	0	3	0	0	0	0	1	0	3	4	0
Melosira,	0	0	0	0	0	0	0	0	6	0	0	0
Meridion,	2	1	4	0	0	0	0	0	0	0	0	0
Synedra,	48	24	116	18	280	1,400	5,840	0	2	24	0	0
Tabellaria,	0	0	1	6	0	7	200	0	4	2	0	0
Cyanophyceæ, Chroöcoccus,	0	0	0	0	0	4	0	0	1	12	0	0
Algæ,	0	pr.	8	30	2	7	10	0	1	4,036	3,286	2,642
Chlorococcus,	0	0	0	0	0	0	0	0	0	24	0	0
Conferva,	0	0	0	0	0	0	0	0	0	4,000	3,280	2,640
Protococcus,	0	0	0	30	0	0	0	0	1	0	0	0
Raphidium,	0	0	0	0	0	5	8	0	0	0	0	0
Scenedesmus,	0	0	0	0	0	2	2	0	0	2	0	2
Selenastrum,	0	0	0	0	0	0	0	0	0	10	0	0
Staurastrum,	0	0	0	0	2	0	0	0	0	0	6	0
Zoöspores,	0	pr.	8	0	0	0	0	0	0	0	0	0
Fungi, Crenothrix,	0	0	4	0	0	32	0	36	2	0	0	0
ANIMALS.												
Rhizopoda, Difflugia,	0	0	0	0	4	0	0	0	1	3	8	0
Infusoria,	88	23	101	19	7	201	109	0	84	14	74	14
Cryptomonas,	0	0	0	8	0	0	0	0	0	0	50	0
Dinobryon,	0	1	0	1	0	0	0	0	0	0	0	0
Dinobryon cases,	4	0	92	6	0	0	0	0	0	0	0	0
Monas,	0	0	8	0	0	0	0	0	3	0	0	0
Peridinium,	84	22	1	4	6	200	108	0	76	9	24	14
Trachelomonas,	0	0	0	0	1	1	1	0	5	5	0	0
Vermes,	0	0	0	6	5	2	5	0	4	5	10	2
Anurea,	0	0	0	1	2	0	0	0	3	2	6	2
Polyarthra,	0	0	0	1	1	0	0	0	0	1	2	0
Rotatorian ova,	0	0	0	1	0	1	2	0	0	1	2	0
Rotifer,	0	0	0	3	2	1	3	0	1	1	0	0
Miscellaneous, Zoöglœa,	0	0	112	128	720	440	1,320	0	84	960	0	0
TOTAL,	138	48	425	212	1,818	2,099	7,484	37	189	5,155	3,382	2,658

QUINCY.

Table showing Heights of Water in the Storage Reservoir of the Quincy Water Works on Dates when Samples of Water were collected for Analysis.

[High-water mark is 86.71 feet above city base.]

1894.	Heights above City Base.	1894.	Heights above City Base.
	Feet.		Feet.
Jan. 24,	83.8	July 24,	82.9
Feb. 26,	86.7	Aug. 21,	80.5
March 26,	86.7	Sept. 25,	78.4
April 23,	86.7	Oct. 23,	77.7
May 21,	86.5	Nov. 27,	82.3
June 25,	85.5	Dec. 26,	85.1

Chemical Examination of Water from the Brook flowing from the Present Storage Reservoir of the Quincy Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13370	Nov. 22	Distinct, milky.	Heavy, rusty.	0.18	5.50	0.95	.0346	.0254	.0192	.0062	.70	.0000	.0001	.0920	2.2
13491	Dec. 17	Decided, milky.	Heavy, rusty.	0.60	5.80	1.30	.0340	.0072	.0052	.0020	.71	.0070	.0000	.0862	1.9
13490	Dec. 17	Slight, milky.	Cons., rusty.	0.20	4.60	2.00	.0136	.0092	.0076	.0016	.62	.0050	.0001	.1155	1.4

Iron, No. 13370, .4000; No. 13491, .3000; No. 13490, .1250. —— Odor of the first two samples, none; of the last, distinctly vegetable. —— The first two samples were collected from the brook below the dam, and the last from the brook a short distance above the point where it is crossed by a road, about 1,000 feet below the dam.

QUINCY.

Microscopical Examination of Water from the Brook flowing from the Present Storage Reservoir of the Quincy Water Works.

[Number of organisms per cubic centimeter.]

	1894.		
	November.	December.	December.
Day of examination,	23	18	18
Number of sample,	13370	13491	13490
PLANTS.			
Diatomaceæ,	**2**	**0**	**2**
Asterionella,	0	0	1
Synedra,	2	0	1
Algæ, Sphærozosma,	**0**	**0**	**15**
Fungi,	**2,560**	**760**	**232**
Crenothrix,	2,560	760	228
Molds,	0	0	4
Miscellaneous, Zoöglœa,	**1,320**	**0**	**0**
TOTAL,	3,882	760	249

Chemical Examination of Water from a Brook North of the Present Storage Reservoir of the Quincy Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13369	Nov. 22	Slight.	Cons.	1.40	5.50	3.05	.0020	.0318	.0226	.0092	.59	.0030	.0000	1.4040	0.8
13489	Dec. 17	V. slight.	Slight.	1.35	4.55	2.10	.0008	.0146	.0116	.0030	.71	.0000	.0000	.7931	0.9

Odor, distinctly vegetable. —— The first sample was collected at the site of a proposed dam; the last sample near the foot of a large gravel bank not far above the junction of this brook with the brook which flows from the present storage reservoir of the Quincy Water Works.

Microscopical Examination.

No. 13369. Diatomaceæ, *Diatoma*, 3; *Epithemia*, 1; *Fragilaria*, 4; *Meridion*, 4; *Navicula*, 7; *Pinnularia*, 5. Fungi, *Crenothrix*, 32; *Molds*, 3. Rhizopoda, *Actinophrys*, 1. Total, 60.

No. 13489. Diatomaceæ, *Asterionella*, 2; *Diatoma*, 1; *Epithemia*, 1; *Gomphonema*, 2; *Meridion*, 3; *Navicula*, 4. Fungi, *Crenothrix*, 5; *Molds*, 1. Total, 19.

QUINCY.

Chemical Examination of Water from Blue Hill River where it is crossed by West Street, Braintree.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
13372	Nov. 22	None.	V. slight.	0.90	4.20	1.90	.0000	.0196	.0172	.0024	.56	.0000	.0000	.8112	0.9

Odor, faintly vegetable.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 1; *Cyclotella*, 1; *Epithemia*, 2; *Grammatophora*, 2; *Synedra*, 5. Rhizopoda, *Difflugia*, 1. Infusoria, *Euglena*, 1. Total, 13.

Water Supply of Randolph and Holbrook.

Chemical Examination of Water from Great Pond in Randolph and Braintree.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11959	Mar. 27	V. slight.	V. slight.	0.68	3.85	1.50	.0000	.0152	.0128	.0024	.59	.0000	.0000	.5505	0.8
12439	June 27	Slight.	Slight.	0.65	4.10	1.95	.0010	.0176	.0156	.0020	.62	.0000	.0000	.5159	1.1
12827	Aug. 27	V. slight.	V. slight.	0.30	4.65	1.75	.0002	.0146	.0128	.0018	.66	.0050	.0000	.3542	1.6
13207	Oct. 24	V. slight.	V. slight.	0.25	4.05	1.50	.0002	.0148	.0136	.0012	.64	.0030	.0000	.3752	1.1
Av.	....	....	....	0.47	4.16	1.68	.0004	.0156	.0137	.0019	.63	.0020	.0000	.4489	1.2

Odor of No. 12827, none; of the other samples, vegetable. —— No. 11959 was collected from a faucet at the pumping station, and the other samples from faucets in Holbrook.

Microscopical Examination.

The total number of organisms per cubic centimeter found in these samples varied from 1 to 27 and averaged 13.

Water Supply of Reading.

Early in 1894 the town of Reading applied to the State Board of Health for advice as to a proposed method of purification of the water supply of that town, and as to the propriety of abandoning the present supply and seeking a new source. In the course of the

investigations of the Board in connection with this application many samples of water were collected for analysis both from the present works and from test wells and other sources within the limits of the town. The results of the analyses of samples of water from the various test wells are given in tables following those giving the results of the regular monthly examinations of the water of the filter-gallery.

Chemical Examination of Water from the Filter-gallery of the Reading Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11606	Jan. 5	Distinct.	Cons., yellow.	0.15	14.50	.0054	.0098	.59	.0000	.0001	.2426	6.3	.1500
11726	Feb. 7	Decided.	Heavy, yellow.	0.75	13.80	.0058	.0102	.56	.0030	.0002	.3704	5.0	.2550
11867	Mar. 8	Decided.	Cons., rusty.	0.70	12.60	.0056	.0116	.57	.0030	.0000	.4640	5.9	.1000
12010	Apr. 9	Decided.	Cons.	0.80	9.40	.0052	.0112	.54	.0030	.0000	.5480	3.5	.1600
12172	May 8	Distinct, milky.	Slight.	0.80	10.60	.0048	.0098	.54	.0030	.0000	.5560	3.5	.1400
12271	May 22	Distinct, floc.	Cons., fibrous.	0.40	9.70	.0034	.0084	.52	.0000	.0000	.3822	3.6	.1100
12345	June 11	Distinct.	Cons.	0.70	9.60	.0066	.0110	.54	.0030	.0000	.5467	3.2	.1160
12520	July 11	Distinct, milky.	Slight, yellow.	0.48	8.10	.0044	.0070	.62	.0070	.0001	.3858	2.3	.0500
12563	July 17	Distinct, milky.	Slight, white.	0.55	8.00	.0036	.0072	.61	.0060	.0000	.3126	2.5	.0900
12738	Aug. 13	Slight.	None.	0.40	8.30	.0054	.0082	.70	.0000	.0000	.2964	2.2	.1000
12912	Sept. 10	Distinct, milky.	Cons., whitish.	0.28	8.00	.0040	.0068	.60	.0000	.0000	.1694	3.1	.0850
13100	Oct. 8	Distinct.	Cons., rusty.	0.40	10.30	.0056	.0036	1.06	.0030	.0000	.1733	3.6	.1800
13274	Nov. 7	Distinct.	Cons., rusty.	0.01	25.60	.0000	.0216	1.00	.0070	.0000	.2864	11.2	.8000
13447	Dec. 5	Decided.	Cons., rusty.	0.03	22.80	.0004	.0182	.81	.0050	.0000	.2957	9.4	1.0300
Av.*	....	....	....	0.45	12.76	.0043	.0107	.68	.0029	.0000	.3509	5.0	.2642

Averages by Years.

-	1891	-	-	0.13	12.96	.0016	.0063	.43	.0094	.0001	-	5.1	-
-	1892	-	-	0.44	9.25	.0042	.0073	.54	.0071	.0001	-	3.4	-
-	1893	-	-	0.64	10.08	.0034	.0087	.56	.0032	.0001	.3497	3.9	.1251
-	1894	-	-	0.45	12.76	.0043	.0107	.68	.0029	.0000	.3509	5.0	.2642

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

NOTE to analyses of 1894: Odor, generally none, sometimes faintly vegetable or unpleasant. —— The samples were collected from a faucet at the pumping station.

READING.

Microscopical Examination of Water from the Filter-gallery of the Reading Water Works.

[Number of organisms per cubic centimeter.]

	1894.													
	Jan.	Feb.	Mar.	Apr.	May.	May	June.	July.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	8	8	9	11	9	24	13	12	18	15	12	9	8	7
Number of sample,	11606	11726	11867	12010	12172	12271	12345	12520	12563	12738	12912	13100	13274	13447
PLANTS.														
Diatomaceæ,	**20**	**0**	**0**	**0**	**15**	**0**	**84**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Asterionella,	0	0	0	0	15	0	0	0	0	0	0	0	0	0
Melosira,	20	0	0	0	0	0	0	0	0	0	0	0	0	0
Synedra,	0	0	0	0	0	0	84	0	0	0	0	0	0	0
Fungi, Crenothrix,	**6,400**	**40,000**	**22,800**	**8,000**	**16,400**	**5,720**	**1,120**	**2,880**	**2,320**	**3,600**	**2,320**	**6,880**	**308**	**2,400**
Miscellaneous, Zoöglœa,	**520**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL,	6,940	40,000	22,800	8,000	16,415	5,720	1,204	2,880	2,320	3,600	2,320	6,880	308	2,400

Chemical Examination of Water from a Tubular Test Well in Bancroft Meadow, Reading.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12197	May 11	None.	None.	0.00	6.10	.0000	.0006	.63	.0900	.0000	.0180	2.2	.0000

Odor, none. —— The sample was collected from the well.

Microscopical Examination.

Diatomaceæ, *Synedra*, 1.

READING.

Chemical Examination of Water from Tubular Test Wells in the Valley of the Ipswich River, about One and One-half Miles above the Reading Pumping Station.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12481	July 6	Slight, milky.	Slight, rusty.	0.60	5.50	.0228	.0006	.28	.0030	.0000	.0308	1.7	.2100
12482	July 6	Distinct, milky.	Cons., rusty.	0.40	6.90	.0028	.0000	.23	.0030	.0000	.0146	2.3	.1570
12483	July 6	Slight, milky.	Cons., sandy.	0.02	6.10	.0000	.0002	.27	.0000	.0000	.1584	1.9	.0100

Odor, none. —— The samples were collected as follows: No. 12481 from well No. 1, located about 1,000 feet south of the river and at the edge of the upland; No. 12482 from well No. 2, located about 300 feet from the river, at the edge of an island in the meadow; No. 12483 from well No. 3, located about 15 feet from the southerly bank of the river.

Microscopical Examination.

Nos. 12481 and 12482. No organisms.
No. 12483 was not examined.

Chemical Examination of Water from a Test Well about One-fourth of a Mile North of Lake Quannapowitt, Reading.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12622	July 27	V. slight, milky.	None.	0.10	8.50	.0116	.0010	.32	.0000	.0000	.0346	3.2	.0450

Odor, none. —— The sample was collected from the well.

Microscopical Examination.

Fungi, *Crenothrix*, 1. Miscellaneous, *Zoögloea*, 76. Total, 77.

READING.

Chemical Examination of Water from the Ipswich River at the Reading Pumping Station.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
12713	1894. Aug. 10	None.	Slight.	0.55	5.90	2.85	.0008	.0152	.0134	.0018	.63	.0000	.0000	.4466	1.3

Odor, none; on heating, distinctly vegetable.——The sample was collected from the river.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 1; *Grammatophora*, 5; *Pinnularia*, 1; *Synedra*, 4; *Tabellaria*, 4. Algæ, *Spirogyra*, 2. Fungi, *Crenothrix*, 7. Rhizopoda, *Amœba*, 1. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoōglœa*, 188. Total, 214.

Water Supply of Revere and Winthrop. — Revere Water Company.

The works of the Revere Water Company for obtaining a supply of ground water at Cliftondale, Saugus, were enlarged in 1893 by sinking 9 tubular wells, and in 1894 by sinking 20 tubular wells, all located in the valley of the brook near the original wells. The new wells are all $2\frac{1}{2}$ inches in diameter, and the total number now connected with these works is 52, ranging in depth from 30 to a little more than 100 feet. They are located on either side of the brook and are included in an area approximately 1,200 feet long by 150 feet wide. The material in which the wells are sunk consists in general of clay, underlaid with a stratum of sand and then one of gravel, beneath which is ledge. The gravel stratum is from 1 to 10 feet in thickness.

It was noted in the last annual report that there was a sudden and very decided increase in 1893 in the quantity of chlorine present in the water of the wells located in Revere, accompanied by a corresponding increase in the residue on evaporation and in hardness, all of which was caused by the infiltration of a small amount of sea water into the wells. During 1894 the chlorine, residue and hardness averaged very much higher than in the previous year, but were much lower at the end of the year than in the months immediately preceding. Some of the samples collected in 1894 contained an excessive amount of iron, a condition which has never been noted

REVERE AND WINTHROP.

before in the water of these wells. In the majority of the samples a slight color was detected, which has not been the case in previous years.

Chemical Examination of Water from the Wells of the Revere Water Company, at Revere.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11581	Jan. 1	Distinct, milky.	Slight.	0.05	99.30	.0000	.0000	34.42	.0600	.0015	.0741	50.0	.0180
11723	Feb. 7	V. slight, milky.	None.	0.02	106.20	.0014	.0028	38.40	.0300	.0012	.0680	49.0	.0085
11850	Mar. 7	None.	None.	0.00	61.45	.0000	.0000	19.78	.1000	.0025	.0760	30.0	.0050
12016	Apr. 10	V. slight.	Cons.	0.01	37.00	.0000	.0004	8.59	.2500	.0000	.0355	16.0	.0100
12017	Apr. 10	Distinct.	Cons.	0.12	66.60	.0006	.0006	20.33	.1000	.0001	.0474	30.0	.1000
12136	May 1	None.	None.	0.00	68.60	.0000	.0000	22.03	.1000	.0023	.0520	31.0	.0000
12205	May 8	None.	None.	0.00	65.20	.0000	.0002	20.96	.2500	.0010	.0546	31.0	.0000
12346	June 11	None.	None.	0.00	66.80	.0000	.0008	20.35	.1800	.0025	.0246	27.0	.0000
12516	July 11	None.	None.	0.02	103.00	.0000	.0008	30.38	.1000	.0012	.0562	44.5	.0070
12745	Aug. 13	None.	None.	0.05	77.80	.0002	.0006	24.73	.1000	.0002	.0385	22.1	.0100
12911	Sept. 10	None.	None.	0.04	145.80	.0002	.0012	46.08	.0800	.0013	.0462	59.5	.0700
13096	Oct. 8	None.	None.	0.01	117.10	.0000	.0024	42.60	.0200	.0015	.0836	57.5	.0040
13315	Nov. 14	Slight.	Cons.	0.01	127.20	.0022	.0030	47.50	.0600	.0020	.0663	59.0	.0850
13486	Dec. 13	Slight.	Cons.	0.04	80.50	.0002	.0010	29.41	.0750	.0002	.0631	39.5	.0000
Av.*				0.03	91.99	.0004	.0011	30.80	.0963	.0013	.0576	41.0	.0219

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
-	1887†	-	-	0.00	22.17	.0002	.0016	3.37	.1670	-	-	-	-
-	1888	-	-	0.00	22.69	.0001	.0022	3.49	.1288	.0022	-	-	-
-	1889‡	-	-	0.00	22.72	.0000	.0016	3.28	.1330	.0027	-	-	-
-	1890§	-	-	0.00	-	.0008	.0012	3.39	.1750	.0024	-	-	-
-	1893	-	-	0.00	50.29	.0002	.0019	13.05	.0907	.0019	.0439	23.0	.0036
-	1894	-	-	0.03	91.99	.0004	.0011	30.80	.0963	.0013	.0576	41.0	.0219

* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December.

‡ January to May.

§ March.

NOTE to analyses of 1894: Odor, none. —— The samples were collected from a faucet at the pumping station.

REVERE AND WINTHROP.

Microscopical Examination of Water from the Wells of the Revere Water Company, at Revere.

[Number of organisms per cubic centimeter.]

	1894.													
	Jan.	Feb.	Mar.	Apr.	Apr.	May	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	8	7	11	11	3	15	13	12	15	12	9	19	17
Number of sample,	11581	11723	11850	12016	12017	12136	12205	12346	12516	12745	12911	13096	13315	13486
PLANTS.														
Diatomaceæ, Synedra,	0	0	0	0	0	0	0	8	0	0	0	0	0	0
Fungi, Crenothrix,	920	2	pr.	840	420	0	0	0	0	0	1	0	1,140	680
TOTAL,	920	2	pr.	840	420	0	0	8	0	0	1	0	1,140	680

Chemical Examination of Water from Tubular Wells of the Revere Water Company, at Cliftondale, Saugus.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
11582	Dec. 30	Distinct, milky.	Slight.	0.00	13.30	.0000	.0000	1.18	.0750	.0050	.0351	6.0	.0140
	1894.												
12336	June 6	None.	None.	0.03	12.80	.0002	.0004	1.19	.0600	.0007	.0308	7.0	.0000
12517	July 11	None.	None.	0.00	13.50	.0000	.0014	1.24	.0700	.0001	.0277	7.0	.0080
13095	Oct. 8	None.	None.	0.02	13.60	.0000	.0018	1.18	.0880	.0000	.0350	6.1	.0020
13276	Nov. 7	None.	None.	0.01	12.20	.0000	.0012	1.40	.0600	.0000	.0000	6.6	.0050
Av.	....	....	....	0.01	13.08	.0000	.0010	1.24	.0706	.0012	.0257	6.5	.0058

Averages by Years.

–	1891*	–	–	0.00	11.50	.0018	.0014	0.88	.0100	.0000	–	5.3	–
–	1892	–	–	0.01	11.65	.0000	.0003	1.16	.0123	.0035	–	6.0	.0116
–	1893	–	–	0.00	12.60	.0002	.0010	1.32	.0872	.0079	.0252	6.4	.0037
–	1894	–	–	0.01	13.08	.0000	.0010	1.24	.0706	.0012	.0257	6.5	.0058

* September.

NOTE to analyses of 1894: Odor, none.—— The samples were collected from faucets in Revere and Saugus supplied wholly from the Saugus wells.

Microscopical Examination.

No. 13095. Fungi, *Crenothrix*, 16.
No. 13276. Fungi, *Crenothrix*, 134.
No organisms were found in the remaining samples.

REVERE AND WINTHROP.

Chemical Examination of Water from the Distributing Reservoir of the Revere Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12337	June 7	Slight.	Slight.	0.03	39.10	.0010	.0050	9.80	.0600	.0012	.0808	18.0	.0000

Odor, distinctly mouldy and grassy. —— The sample was collected from the reservoir.

Microscopical Examination.

No. 12337. Diatomaceæ, *Synedra*, 5,040. Algæ, *Protococcus*, 1. Infusoria, *Peridinium*, 172. Total, 5,213.

Chemical Examination of Water from a Fountain in Winthrop, supplied from the Works of the Revere Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12845	Aug. 30	None.	None.	0.00	77.50	.0000	.0004	25.90	.0600	.0000	.0308	36.6	.0050

Odor, none.

Microscopical Examination.

Diatomaceæ, *Synedra*, 7.

Water Supply of Rockland.

(See *Abington.*)

ROCKPORT.

Water Supply of Rockport.

Works for the supply of Rockport were nearly completed at the end of 1894, the source of supply being Cape Pond, located within the limits of the town. Analyses of samples of water from this pond are given in the following table, and a statement as to the pond and the quality of its water may be found in the annual report of the State Board of Health for 1893, pages 45–47.

A communication from the Board to the Water Commissioners of Rockport, relative to the prevention of the pollution of Cape Pond by the waste matters from a glue factory, may be found on page 65 of this volume.

Chemical Examination of Water from Cape Pond, Rockport.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11805	Feb. 26	Distinct.	V. slight.	0.08	13.40	1.60	.0000	.0210	.0150	.0060	6.20	.0030	.0000	.2200	1.4
12276	May 23	Distinct.	Cons., white.	0.18	12.55	2.35	.0000	.0178	.0126	.0052	5.20	.0000	.0000	.2067	1.1
12493	July 9	Decided, green.	Cons., brown.	0.08	12.50	2.00	.0008	.0284	.0162	.0122	5.54	.0000	.0000	.2156	1.2
12783	Aug. 20	Distinct, green.	Slight, brown.	0.25	12.55	2.05	.0000	.0286	.0196	.0090	4.80	.0000	.0000	.2233	1.2
13341	Nov. 20	Slight.	Slight.	0.30	13.05	1.95	.0000	.0166	.0136	.0030	6.00	.0000	.0000	.2418	1.4
13522	Dec. 19	Slight.	Slight.	0.40	13.05	1.50	.0000	.0226	.0206	.0020	5.56	.0030	.0000	.3657	1.3
Av.	....	....	....	0.22	12.85	1.91	.0001	.0225	.0163	.0062	5.55	.0010	.0000	.2455	1.3

Odor, generally vegetable, sometimes none. —— The samples were collected from the pond.

ROCKPORT.

Microscopical Examination of Water from Cape Pond, Rockport.

[Number of organisms per cubic centimeter.]

	1894.					
	Feb.	May.	July.	Aug.	Nov.	Dec.
Day of examination,	27	24	10	22	22	20
Number of sample,	11805	12276	12493	12783	13341	13522
PLANTS.						
Diatomaceæ, Asterionella,	248	9,280	5	10	2,320	3,250
Cyanophyceæ,	0	0	2,400	20	8	0
Anabæna,	0	0	1,360	5	0	0
Anabæna spores,	0	0	1,040	0	0	0
Chroöcoccus,	0	0	0	0	8	0
Clathrocystis,	0	0	0	15	0	0
Algæ,	3	0	2	352	12	0
Chlorococcus,	0	0	0	4	8	0
Closterium,	0	0	0	340	1	0
Glœocystis,	3	0	0	0	0	0
Pediastrum,	0	0	2	6	2	0
Staurastrum,	0	0	0	2	1	0
Fungi, Crenothrix,	80	0	72	160	0	0
ANIMALS.						
Infusoria,	185	271	0	227	1	50
Dinobryon,	0	16	0	0	0	0
Dinobryon cases,	184	248	0	0	0	0
Euglena,	0	0	0	1	0	0
Mallomonas,	0	0	0	2	0	0
Monas,	1	0	0	0	0	50
Peridinium,	0	7	0	64	1	0
Trachelomonas,	0	0	0	160	0	0
Vermes,	0	1	0	2	3	0
Anurea,	0	1	0	1	2	0
Monocerca,	0	0	0	1	0	0
Polyarthra,	0	0	0	0	1	0
Miscellaneous, Zoöglœa,	32	0	156	0	0	0
TOTAL,	548	9,552	2,635	771	2,344	3,300

WATER SUPPLY OF SALEM AND BEVERLY.

During the year 1894 Wenham Lake was drawn to a lower level than ever before, the lowest point reached up to the end of November being about 11 feet below high-water mark. Works for in-

creasing the supply of Salem and Beverly by diverting the waters of Longham Brook into Wenham Lake were begun in the latter part of the year.

Chemical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894														
11618	Jan. 10	Slight.	Slight.	0.06	5.55	1.10	.0036	.0094	.0084	.0010	.80	.0040	.0000	.1178	2.6
11715	Feb. 6	Distinct.	Slight.	0.01	5.90	1.20	.0088	.0136	.0112	.0024	.80	.0050	.0001	.1232	2.7
11846	Mar. 6	Slight.	Slight.	0.02	6.55	1.55	.0052	.0146	.0108	.0038	.79	.0070	.0001	.1600	2.7
11993	Apr. 4	Slight.	V. slight.	0.05	6.40	1.25	.0004	.0134	.0096	.0038	.78	.0050	.0000	.1116	2.7
12175	May 8	Distinct.	Cons.	0.05	5.95	1.30	.0000	.0130	.0090	.0040	.80	.0000	.0001	.1747	2.9
12449	June 30	Slight.	Slight.	0.03	6.80	1.85	.0016	.0106	.0078	.0028	.82	.0000	.0000	.1771	3.2
12617	July 26	Distinct.	Slight, green.	0.07	6.85	1.75	.0002	.0164	.0110	.0054	.86	.0020	.0000	.1578	3.1
12708	Aug. 10	Distinct, green.	Distinct, green.	0.08	7.40	2.15	.0030	.0254	.0192	.0062	.85	.0000	.0000	.0924	3.3
12969	Sept. 17	Slight.	Slight.	0.07	7.70	2.00	.0018	.0144	.0112	.0032	.82	.0000	.0000	.1540	2.9
13106	Oct. 9	Slight.	Cons.	0.05	7.15	1.60	.0020	.0134	.0118	.0016	.82	.0000	.0000	.1140	3.2
13296	Nov. 12	Slight.	Cons., green.	0.12	7.10	1.55	.0078	.0172	.0126	.0046	.83	.0030	.0002	.1482	3.5
13462	Dec. 10	Slight.	V. slight.	0.28	6.90	1.05	.0016	.0164	.0146	.0018	.81	.0020	.0001	.1078	3.4
Av.	....	....	....	0.07	6.69	1.53	.0030	.0148	.0114	.0034	.82	.0023	.0001	.1366	3.0

Averages by Years.

-	1887*	-	-	0.05	4.73	0.82	.0025	.0135	-	-	.72	.0019	-	-	-
-	1888	-	-	0.05	4.67	0.97	.0020	.0146	-	-	.73	.0058	.0001	-	-
-	1889	-	-	0.06	4.23	1.05	.0014	.0173	.0138	.0035	.72	.0052	.0002	-	-
-	1890	-	-	0.05	4.57	0.90	.0016	.0154	.0125	.0029	.74	.0104	.0001	-	2.5
-	1891	-	-	0.07	4.70	1.12	.0006	.0147	.0113	.0034	.72	.0125	.0000	-	1.9
-	1892	-	-	0.03	4.85	1.10	.0016	.0137	.0103	.0034	.75	.0077	.0000	-	2.2
-	1893	-	-	0.04	5.49	1.26	.0033	.0130	.0100	.0030	.77	.0055	.0001	.1605	2.6
-	1894	-	-	0.07	6.69	1.53	.0030	.0148	.0114	.0034	.82	.0023	.0001	.1366	3.0

* June to December.

Note to analyses of 1894: Odor, generally vegetable, sometimes unpleasant or disagreeable; on heating, generally stronger and more frequently unpleasant. —— The first four and the last two samples were collected from faucets at the pumping station, and the remaining samples from the lake.

SALEM AND BEVERLY.

Microscopical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	July.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Date of examination, .	10	7	7	5	10	2	27	14	18	10	13	11
Number of sample, . .	11618	11715	11846	11993	12175	12449	12617	12708	12969	13106	13296	13462
PLANTS.												
Diatomaceæ, . .	**184**	**535**	**463**	**1,810**	**3,753**	**448**	**220**	**106**	**254**	**649**	**3,936**	**1,932**
Asterionella, . .	32	62	102	720	3,040	5	0	0	30	220	2,920	904
Cyclotella, . . .	128	360	250	280	620	232	56	8	0	1	4	44
Fragilaria, . . .	20	16	10	29	55	0	0	8	0	0	0	0
Melosira, . . .	3	74	90	640	24	3	0	2	0	80	312	0
Nitzschia, . . .	0	0	4	0	2	0	0	0	0	0	0	0
Stephanodiscus, . .	0	3	2	52	0	0	0	0	0	0	60	40
Synedra, . . .	1	14	1	72	2	0	0	4	0	0	0	0
Tabellaria, . . .	0	6	4	17	10	208	164	84	224	348	640	944
Cyanophyceæ, . .	**0**	**0**	**0**	**0**	**0**	**70**	**253**	**80**	**166**	**0**	**0**	**0**
Anabæna, . . .	0	0	0	0	0	29	180	64	164	0	0	0
Clathrocystis, . .	0	0	0	0	0	1	9	10	2	0	0	0
Microcystis, . . .	0	0	0	0	0	40	64	6	0	0	0	0
Algæ, ...	**166**	**128**	**0**	**41**	**0**	**240**	**0**	**0**	**0**	**38**	**0**	**8**
Chlorococcus, . .	0	0	0	41	0	220	0	0	0	0	0	0
Protococcus, . .	166	128	0	0	0	0	0	0	0	38	0	8
Raphidium, . . .	0	0	0	0	0	20	0	0	0	0	0	0
ANIMALS.												
Rhizopoda, Actinophrys, .	**0**	**14**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Infusoria, . . .	**2**	**15**	**1**	**36**	**79**	**14**	**2**	**1**	**5**	**117**	**0**	**0**
Ceratium, . . .	0	0	0	0	0	6	1	0	2	0	0	0
Dinobryon, . . .	0	0	0	12	0	0	0	0	0	0	0	0
Dinobryon cases, .	0	3	0	22	72	7	0	0	0	112	0	0
Mallomonas, . .	0	0	0	0	3	0	0	0	0	1	0	0
Peridinium, . .	2	2	1	1	1	1	1	1	2	0	0	0
Trachelomonas, . .	0	10	0	1	3	0	0	0	1	4	0	0
Miscellaneous, Zoöglœa, .	**0**	**28**	**0**	**0**	**4**	**20**	**132**	**156**	**40**	**0**	**0**	**0**
TOTAL, ...	352	720	464	1,887	3,836	792	607	343	465	804	3,936	1,940

SALEM AND BEVERLY.

Table showing Heights of Water in Wenham Lake at Times when Samples of Water were collected for Analysis.

[NOTE. — High-water mark is 30.17 feet.]

Date.	Height of Water.	Date.	Height of Water.
1894.	Feet.	1894.	Feet.
Jan. 10,	21.18	July 26,	21.56
Feb. 6,	21.34	Aug. 10,	21.04
March 6,	21.63	Sept. 17,	19.76
April 4,	22.63	Oct. 9,	19.34
May 8,	23.12	Nov. 12,	19.31
June 30,	22.67	Dec. 10,	19.08

Chemical Examination of Water from an Ice-pond, Salem.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11703	Feb. 1	Slight, clayey.	Slight, white.	0.20	6.90	1.85	.0026	.0240	.0164	.0076	.61	.0250	.0000	.4993	3.1

Odor, distinctly earthy, becoming also unpleasant on heating. —— The sample was collected from the pond, which is an overflowed meadow, said to cover $1\frac{1}{2}$ to 2 acres, located near Gallows Hill.

WATER SUPPLY OF SAUGUS.

(See *Lynn.*)

WATER SUPPLY OF SHARON. — SHARON WATER COMPANY.

Chemical Examination of Water from the Well of the Sharon Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12614	July 25	None.	None.	0.00	9.20	.0000	.0000	1.00	.2500	.0000	.0000	3.0	.0200

Odor, none. —— The sample was collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No organisms.

WATER SUPPLY OF SOMERVILLE.

(See *Boston, Mystic Works.*)

SPENCER.

Chemical Examination of Water from Turkey Hill Brook, Shaw Brook and Stiles Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
13213	Oct. 24	V. slight.	V. slight.	0.90	4.75	2.15	.0004	.0248	.0228	.0020	.19	.0030	.0000	.9124	1.6
13214	Oct. 24	Decided.	Heavy, brown.	0.75	4.90	1.60	.0010	.0486	.0280	.0206	.26	.0080	.0000	.6833	1.4
13221	Oct. 25	Distinct.	Cons., green.	1.00	3.25	1.90	.0086	.0304	.0214	.0090	.17	.0000	.0000	.6833	0.5

Odor of the first two samples, very faintly vegetable; of the third, decidedly vegetable and unpleasant. —— The first sample was collected from Turkey Hill Brook above Wire Village; the second from a pond on Shaw Brook at Wire Village; the last from Stiles Reservoir. The samples were collected while making an examination of possible sources of water supply for the city of Worcester.

Microscopical Examination.

No. 13213. Total number of organisms, 18.

No. 13214. Total number of organisms, 2,090, chiefly Diatomaceæ (*Asterionella*, 888, and *Synedra*, 832).

No. 13221. Total number of organisms, 681, chiefly Diatomaceæ.

SPRINGFIELD.

Water Supply of Springfield.

Chemical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11585	Jan. 2	V. slight.	V. slight.	0.53	3.90	1.45	.0004	.0112	.0092	.0020	.16	.0030	.0000	.5382	1.1
11710	Feb. 5	V. slight.	Slight.	0.33	3.65	1.10	.0012	.0108	.0094	.0014	.18	.0090	.0000	.3792	1.3
11843	Mar. 5	V. slight.	Cons., green.	0.50	3.35	1.40	.0070	.0216	.0158	.0058	.14	.0030	.0000	.5064	0.8
11992	Apr. 3	V. slight.	V. slight.	0.53	3.60	1.50	.0000	.0142	.0120	.0022	.15	.0030	.0000	.4366	0.9
12150	May 2	Distinct.	Slight, brown.	0.50	3.30	1.20	.0004	.0158	.0128	.0030	.17	.0000	.0000	.5216	0.9
12314	June 5	Distinct.	Slight.	0.70	2.45	1.00	.0008	.0192	.0164	.0028	.12	.0000	.0000	.5775	1.1
12495	July 9	Decided.	Slight, brown.	0.45	3.75	1.25	.0000	.0230	.0180	.0050	.17	.0030	.0000	.3811	1.8
12674	Aug. 7	Distinct.	Cons., brown.	0.65	3.85	1.50	.0004	.0254	.0194	.0060	.15	.0020	.0000	.3927	1.3
12886	Sept. 5	Distinct, green.	Cons., yellow.	0.50	3.90	1.75	.0000	.0316	.0194	.0122	.15	.0000	.0001	.3426	1.4
13079	Oct. 3	Distinct.	Cons.	0.22	3.95	1.70	.0002	.0244	.0172	.0072	.18	.0000	.0000	.4345	1.7
13264	Nov. 6	Slight.	Cons.	0.68	4.75	1.80	.0008	.0234	.0188	.0046	.23	.0060	.0000	.6429	1.8
13442	Dec. 5	Slight.	Slight.	0.32	3.70	1.35	.0008	.0146	.0124	.0022	.15	.0030	.0000	.4081	1.6
Av.	....	....	....	0.49	3.68	1.42	.0010	.0196	.0151	.0045	.16	.0027	.0000	.4635	1.6

Averages by Years.

–	1891	–	–	0.31	3.27	1.20	.0011	.0225	.0147	.0078	.09	.0049	.0001	–	1.0
–	1892	–	–	0.44	3.79	1.39	.0004	.0164	.0127	.0037	.14	.0089	.0001	–	1.3
–	1893	–	–	0.49	3.76	1.39	.0009	.0204	.0146	.0058	.15	.0026	.0001	.5132	1.2
–	1894	–	–	0.49	3.68	1.42	.0010	.0196	.0151	.0045	.16	.0027	.0000	.4635	1.6

NOTE to analyses of 1894: Odor, generally distinctly vegetable, frequently also grassy, mouldy or unpleasant; sometimes none. —— The samples were collected in the gate-house.

SPRINGFIELD.

Microscopical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	6	7	5	3	6	10	8	6	5	8	7
Number of sample,	11585	11710	11843	11992	12150	12314	12495	12674	12886	13079	13264	13442
PLANTS.												
Diatomaceæ,	5	11	16	16	288	30	86	100	1,105	3,287	92	31
Asterionella,	0	0	0	2	4	0	49	17	840	3,200	64	19
Cymbella,	0	0	1	pr.	40	0	0	1	2	0	0	0
Fragilaria,	0	0	0	0	2	0	5	10	0	3	0	2
Melosira,	0	2	3	0	85	30	29	23	260	80	18	3
Meridion,	0	0	6	pr.	1	0	0	0	0	0	0	1
Navicula,	1	3	3	2	3	0	3	1	1	1	3	2
Synedra,	4	5	3	10	152	0	0	48	2	3	4	1
Tabellaria,	0	1	0	2	1	0	0	0	0	0	3	3
Cyanophyceæ,	0	0	0	0	0	3	4	68	3	0	0	0
Anabæna,	0	0	0	0	0	0	0	64	3	0	0	0
Clathrocystis,	0	0	0	0	0	3	4	4	0	0	0	0
Algæ,	0	0	0	0	1	1	1	96	21	110	43	2
Cœlastrum,	0	0	0	0	0	0	0	0	3	4	0	0
Dictyosphærium,	0	0	0	0	0	0	0	6	0	0	0	0
Pediastrum,	0	0	0	0	0	1	0	3	4	6	0	0
Protococcus,	0	0	0	0	0	0	0	10	0	0	0	0
Scenedesmus,	0	0	0	0	1	0	0	1	3	32	20	0
Selenastrum,	0	0	0	0	0	0	0	0	0	0	20	0
Staurastrum,	0	0	0	0	0	0	1	72	11	64	3	2
Staurogenia,	0	0	0	0	0	0	0	4	0	4	0	0
Fungi, Crenothrix,	pr.	0	0	1	5	3	0	0	0	1	4	1
ANIMALS.												
Infusoria,	6	4	0	4	19	137	71	301	37	48	5	11
Dinobryon,	0	3	0	0	0	120	6	10	0	0	0	0
Dinobryon cases,	0	0	0	0	17	10	65	280	0	3	0	3
Euglena,	0	0	0	0	0	4	0	0	0	0	0	1
Mallomonas,	0	0	0	0	0	3	0	2	1	7	2	0
Peridinium,	6	1	0	4	1	0	0	1	0	2	3	7
Trachelomonas,	0	0	0	0	1	0	0	8	36	36	0	0
Vermes,	pr.	0	0	0	0	0	0	3	4	0	2	0
Anurea,	0	0	0	0	0	0	0	0	1	0	1	0
Monocerca,	0	0	0	0	0	0	0	3	2	0	1	0
Rotifer,	pr.	0	0	0	0	0	0	0	1	0	0	0
Miscellaneous, Zoöglœa,	0	2	0	0	60	2	0	0	0	580	0	0
TOTAL,	11	17	16	21	373	176	162	568	1,170	4,026	146	45

SPRINGFIELD.

Chemical Examination of Water from Ludlow Reservoir.

[Parts per 100,000]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11586	Jan. 2	Slight.	V. slight.	0.40	3.75	1.50	.0006	.0174	.0118	.0056	.15	.0040	.0001	.5070	0.9
11709	Feb. 5	Slight.	Slight.	0.33	3.85	1.55	.0068	.0168	.0136	.0032	.19	.0070	.0000	.4672	1.3
11842	Mar. 5	V. slight.	Slight.	0.30	3.45	1.40	.0006	.0120	.0096	.0024	.14	.0000	.0000	.4000	0.6
11991	Apr. 3	Slight.	Slight.	0.35	3.60	1.70	.0008	.0172	.0140	.0032	.17	.0000	.0000	.3888	0.8
12149	May 2	Distinct.	Slight.	0.25	2.75	1.15	.0000	.0160	.0120	.0040	.17	.0000	.0000	.4160	0.8
12313	June 5	Slight.	Slight.	0.45	3.10	1.15	.0002	.0224	.0174	.0050	.13	.0050	.0000	.3734	1.1
12494	July 9	Decided.	Cons., brown.	0.50	3.45	1.55	.0000	.0272	.0212	.0060	.18	.0000	.0000	.4012	0.9
12675	Aug. 7	Distinct.	Cons., brown.	0.65	3.75	1.50	.0010	.0272	.0198	.0074	.15	.0020	.0000	.3696	1.6
12885	Sept. 5	Decided, green.	Cons., green.	0.53	3.75	1.85	.0000	.0326	.0200	.0126	.18	.0000	.0001	.3388	1.6
13080	Oct. 3	Distinct.	Cons.	0.20	3.55	1.55	.0000	.0288	.0190	.0098	.17	.0000	.0000	.5846	1.5
13263	Nov. 6	Slight.	Cons.	0.25	3.00	1.30	.0000	.0268	.0210	.0058	.18	.0000	.0000	.3557	1.1
13443	Dec. 5	V. slight.	Slight.	0.28	2.65	1.40	.0002	.0210	.0184	.0026	.15	.0030	.0000	.4196	0.9
Av.	....	....	....	0.37	3.39	1.47	.0009	.0221	.0165	.0056	.16	.0018	.0000	.4185	1.1

Averages by Years.

–	1876-77*	–	–	–	4.86	–	.0139	.0426	.0296	.0130	–	–	–	–	–
–	1887†	–	–	0.24	3.63	1.65	.0030	.0486	–	–	.15	.0019	–	–	–
	1888	–	–	0.13	2.91	1.20	.0019	.0332	–	–	.12	.0047	.0001	–	–
–	1889	–	–	0.11	2.42	1.07	.0028	.0461	.0237	.0224	.10	.0033	.0002	–	–
–	1890	–	–	0.15	2.96	1.54	.0029	.0387	.0210	.0177	.10	.0065	.0001	–	0.9
–	1891	–	–	0.20	3.00	1.42	.0050	.0425	.0228	.0197	.09	.0050	.0001	–	0.8
–	1892‡	–	–	0.25	3.41	1.41	.0006	.0277	.0189	.0088	.13	.0049	.0001	–	1.0
–	1893§	–	–	0.47	4.11	2.03	.0011	.0375	.0259	.0116	.14	.0019	.0001	.5779	1.2
–	1894	–	–	0.37	3.39	1.47	.0009	.0221	.0165	.0056	.16	.0018	.0000	.4185	1.1

* These analyses were made by Prof. William R. Nichols, for the city of Springfield, from samples collected about once a week, between July 1, 1876, and Sept. 30, 1877.

† June to December. ‡ January to September. § May to December.

NOTE to analyses of 1894: Odor, vegetable, frequently also mouldy or unpleasant. —— The samples were collected from the reservoir, at depths of from 1 to 3 feet beneath the surface.

For record of heights of water on dates when samples of water were collected for analysis, see page 314.

SPRINGFIELD.

Microscopical Examination of Water from Ludlow Reservoir.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	6	7	5	3	6	10	8	6	5	8	7
Number of sample,	11586	11709	11842	11991	12149	12313	12494	12675	12885	13080	13263	13443
PLANTS.												
Diatomaceæ,	1	pr.	0	72	760	1	81	51	1,951	1,623	338	25
Asterionella,	1	0	0	0	240	0	0	19	1,840	1,600	296	24
Cyclotella,	0	0	0	1	0	1	80	0	0	0	2	0
Fragilaria,	0	0	0	0	0	0	0	0	5	6	0	0
Melosira,	0	0	0	7	0	0	0	0	56	17	37	0
Synedra,	0	0	0	52	480	0	0	32	48	0	2	1
Tabellaria,	0	pr.	0	12	40	0	1	0	2	0	1	0
Cyanophyceæ, Anabæna,	0	0	0	0	0	0	0	88	6	0	0	0
Algæ,	3	0	pr.	6	8	18	16	208	55	149	426	0
Chlorococcus,	0	0	0	3	0	12	15	0	0	0	0	0
Closterium,	0	0	pr.	0	0	2	0	0	1	0	8	0
Cœlastrum,	0	0	0	0	0	0	0	0	8	28	1	0
Cosmarium,	1	0	0	0	0	1	0	0	0	2	2	0
Pediastrum,	0	0	0	pr.	0	3	0	1	13	7	3	0
Protococcus,	2	0	0	0	0	0	0	148	8	0	248	0
Raphidium,	0	0	0	pr.	0	0	0	0	0	0	32	0
Scenedesmus,	0	0	0	3	8	0	1	7	18	76	108	0
Staurastrum,	0	0	0	0	0	0	0	52	7	36	24	0
Fungi, Crenothrix,	0	0	pr.	1	56	0	1	0	5	0	3	0
ANIMALS.												
Infusoria,	210	126	38	134	458	33	2	397	18	127	112	6
Dinobryon,	0	18	0	0	86	10	0	0	0	0	4	0
Dinobryon cases,	0	24	0	5	300	20	0	360	0	60	84	4
Mallomonas,	0	0	0	1	0	3	0	0	0	24	2	0
Peridinium,	210	84	38	128	72	0	0	1	0	3	9	2
Trachelomonas,	0	0	0	0	0	0	2	36	18	40	13	0
Vermes,	1	pr.	pr.	1	1	0	4	2	3	2	2	0
Anurea,	pr.	pr.	pr.	0	0	0	0	1	0	0	1	0
Monocerca,	0	0	0	0	0	0	1	1	0	1	1	0
Phacus,	0	0	0	0	0	0	0	0	2	1	0	0
Polyarthra,	1	0	0	0	0	0	2	0	0	0	0	0
Rotatorian ova,	pr.	0	0	1	0	0	1	0	0	0	0	0
Rotifer,	0	0	pr.	0	1	0	0	0	1	0	0	0
Miscellaneous, Zoöglœa,	0	0	0	0	0	8	56	0	128	400	68	0
TOTAL,	215	126	38	214	1,283	60	160	746	2,166	2,301	949	31

SPRINGFIELD.

Chemical Examination of Water from Jabish Brook and from Knight and Gold Reservoir, Belchertown.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11786	Feb. 19	V. slight.	Cons., earthy.	0.70	3.05	1.35	.0000	.0126	.0102	.0024	.14	.0090	.0000	.7136	0.3
11787	Feb. 19	None.	V. slight.	0.63	3.15	1.15	.0006	.0118	.0106	.0012	.16	.0120	.0000	.6560	0.2

Odor of the first sample, distinctly vegetable; of the second, faintly vegetable, becoming stronger on heating. —— The first sample was collected from Jabish Brook, just above Pratt's Reservoir; the second, from the Knight and Gold Reservoir on Jabish Brook. The latter reservoir is the lower one of the two reservoirs, highest up Jabish Brook, which were purchased by the city of Springfield for use as storage reservoirs. For a description of this reservoir see Annual Report for 1891, page 206.

Microscopical Examination.

No. 11786. Diatomaceæ, *Epithemia*, 2; *Synedra*, 20; *Tabellaria*, 1. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoöglœa*, 38. Total, 62.

No. 11787. Algæ, *Cosmarium*, 4. Infusoria, *Dinobryon*, 3; *Peridinium*, 6. Total, 13.

Table showing Heights of Water in Ludlow Reservoir at times when Samples of Water were collected for Analysis in 1894.

Note. — Height of rollway, 28.1 feet above bottom of reservoir.

Date.	Height of Water above Bottom of Reservoir.	Date.	Height of Water above Bottom of Reservoir.
1894.	Feet.	**1894.**	Feet.
Jan. 2,	18.70	July 9,	27.44
Feb. 5,	20.93	Aug. 7,	25.90
March 5,	23.18	Sept. 5,	24.41
April 3,	28.01	Oct. 3,	23.70
May 2,	28.21	Nov. 6,	23.81
June 5,	28.49	Dec. 5,	24.08

Water Supply of Stockbridge. — Stockbridge Water Company.

Chemical Examination of Water from Lake Averic, Stockbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12748	Aug. 14	Slight.	V. slight.	0.15	6.45	1.60	.0010	.0190	.0172	.0018	.06	.0000	.0000	.3157	4.0
13212	Oct. 24	None.	V. slight.	0.12	7.00	1.60	.0004	.0210	.0178	.0032	.10	.0030	.0000	.3018	4.9

Odor of the first sample, distinctly mouldy, becoming disagreeable on heating; of the second sample, distinctly vegetable and unpleasant. —— The samples were collected from the lake.

Microscopical Examination.

No. 12748. Cyanophyceæ, *Anabæna*, 2; *Clathrocystis*, 3. Algæ, *Protococcus*, 13. Infusoria, *Peridinium*, 68. Total, 86.

No. 13212. Diatomaceæ, *Cymbella*, 1; *Fragilaria*, 4; *Gomphonema*, 1; *Melosira*, 4; *Synedra*, 1. Infusoria, *Cryptomonas*, 100. Vermes, *Anurea*, 5; *Polyarthra*, 1; *Rotatorian ova*, 1. Crustacea, *Cyclops*, .01. Total, 118.

Water Supply of Stoneham.

(See *Wakefield*.)

Water Supply of Stoughton.

Chemical Examination of Water from a Faucet at the Pumping Station of the Stoughton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11666	Jan. 22	None.	None.	0.12	3.30	–	.0000	–	–	–	.32	.0100	.0000	.1248	1.1
12158	May 7	None.	V. slight.	0.10	3.25	0.85	.0002	.0058	.0046	.0012	.33	.0030	.0000	.1804	0.6
12619	July 26	V. slight.	Slight.	0.28	3.10	0.85	.0000	.0086	.0066	.0020	.31	.0050	.0000	.2225	0.9
13181	Oct. 22	None.	Slight.	0.25	3.90	1.10	.0000	.0060	.0048	.0012	.35	.0050	.0000	.2275	1.3
Av.	....	....	....	0.19	3.39	0.93	.0001	.0068	.0053	.0015	.33	.0058	.0000	.1888	1.0

Odor of No. 11666, none; of Nos. 12158 and 13181, vegetable; of No. 12619, faintly mouldy. —— The samples were collected from faucets, the last two at the pumping station.

STOUGHTON.

Microscopical Examination of Water from a Faucet at the Pumping Station of the Stoughton Water Works.

[Number of organisms per cubic centimeter.]

	1894.			
	January.	May.	July.	October.
Day of examination,	24	8	27	24
Number of sample,	11666	12158	12619	13181
PLANTS.				
Diatomaceæ,	4	7	1	0
Asterionella,	0	2	0	0
Diatoma,	3	0	0	0
Synedra,	1	5	1	0
Algæ, Raphidium,	0	2	0	0
Fungi, Crenothrix,	0	6	52	6
ANIMALS.				
Rhizopoda, Euglypha,	10	0	0	0
Infusoria,	0	1	1	0
Dinobryon cases,	0	1	0	0
Peridinium,	0	0	1	0
TOTAL,	14	16	54	6

Chemical Examination of Water from a Brook and Test Well, collected during an Investigation for an Additional Water Supply for Stoughton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13454	Dec. 5	V. slight.	Slight.	0.75	9.30	3.05	.0046	.0158	.0150	.0008	1.35	.1800	.0005	.5852	2.9
13455	Dec. 5	None.	None.	0.00	3.40	–	.0004	.0012	–	–	.38	.0000	.0000	.0308	0.8

Odor of the first sample, faintly vegetable; of the second, none. —— The first sample was collected from a brook flowing from the village, just below Southworth's stone mill; the second sample from a test well 50 feet from French and Ward's millpond on Muddy Pond Brook.

Microscopical Examination.

No. 13454. Diatomaceæ, *Cyclotella*, 2; *Diatoma*, 1; *Melosira*, 5; *Meridion*, 1; *Synedra*, 20; *Tabellaria*, 2. Algæ, *Scenedesmus*, 3; *Tetrapedia*, 1. Total, 35.

No. 13455. No organisms.

Water Supply of Swampscott and Nahant. — Marblehead Water Company.

The advice of the State Board of Health to the Marblehead Water Company, relative to the use of Floating Bridge Pond in Lynn as a source of public water supply for the towns of Swampscott and Nahant, may be found on pages 41 and 42 of this volume. An analysis of a sample of water collected from the pond may be found on the following page.

Chemical Examination of Water from the Wells of the Marblehead Water Company, Swampscott.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11590	Jan. 3	None.	None.	0.00	12.70	.0000	.0004	1.19	.0600	.0000	.0429	5.8	.0000
11721	Feb. 7	None.	None.	0.00	12.20	.0000	.0008	1.25	.0700	.0000	.0224	6.0	.0000
11853	Mar. 7	None.	None.	0.00	11.90	.0000	.0010	1.20	.0400	.0000	.0440	6.0	.0100
12011	Apr. 9	V. slight.	None.	0.03	11.70	.0000	.0022	1.14	.0750	.0000	.0840	5.6	.0060
12184	May 8	None.	None.	0.04	10.80	.0000	.0032	1.19	.0700	.0000	.0902	5.6	.0000
12351	June 11	None.	None.	0.02	13.10	.0000	.0012	1.21	.0600	.0000	.0323	5.7	.0160
12498	July 10	None.	None.	0.02	22.20	.0016	.0016	4.20	.1500	.0000	.0231	9.6	.0060
12581	July 18	V. slight.	V. slight.	0.02	14.40	.0000	.0008	2.04	.1000	.0001	.0115	6.4	.0160
12742	Aug. 13	None.	V. slight.	0.03	48.65	.0000	.0018	16.71	.5500	.0000	.0323	13.5	.0040
12950	Sept. 10	None.	V. slight.	0.20	84.50	.0000	.0008	25.48	.5000	.0000	.0385	32.0	.0050
13124	Oct. 8	None.	None.	0.07	94.60	.0000	.0030	31.78	.8300	.0000	.0684	44.5	.0000
13277	Nov. 7	V. slight, milky.	None.	0.05	72.30	.0004	.0030	22.70	.7000	.0001	.0808	28.5	.0200
13448	Dec. 5	None.	None.	0.00	63.40	.0010	.0026	19.30	.5000	.0000	.0539	28.5	.0070
Av.*	....	....	....	0.04	37.84	.0002	.0018	10.52	.2983	.0000	.0506	15.8	.0066

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
–	1887†	–	–	0.03	23.88	.0032	.0028	2.94	.5302	–	–	–	–
–	1888	–	–	0.00	25.16	.0007	.0035	3.26	.4477	.0003	–	–	–
–	1889‡	–	–	0.00	26.20	.0006	.0033	3.80	.4390	.0002	–	–	–
–	1890§	–	–	0.00	44.00	.0006	.0010	8.30	.6250	.0001	–	21.2	–
–	1891	–	–	0.00	38.64	.0018	.0010	7.73	.9909	.0002	–	18.0	–
–	1892	–	–	0.00	54.94	.0000	.0010	14.53	.7437	.0000	–	22.0	–
–	1893	–	–	0.01	46.42	.0000	.0022	12.12	.4263	.0000	.0747	14.7	.0061
–	1894	–	–	0.04	37.84	.0002	.0018	10.52	.2983	.0000	.0506	15.8	.0066

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† June to December.

‡ January to May.

§ October.

Note to analyses of 1894: Odor, none. —— No. 12498 was collected from the large well, and the other samples from a faucet at the pumping station.

Microscopical Examination.

A very few organisms were found in the samples collected in April, June and July, and none in the others.

SWAMPSCOTT AND NAHANT.

Chemical Examination of Water from Tubular Wells of the Marblehead Water Company on Paradise Road, Swampscott.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12579	July 18	None.	Slight, earthy.	0.0	13.50	.0008	.0000	1.41	.0500	.0002	.0000	5.7	.0260

Odor, none.—— The sample was collected from a temporary pump drawing water from the wells in Paradise Road.

Microscopical Examination.

Fungi, *Crenothrix*, 84.

Chemical Examination of Water from the Tubular Wells of the Marblehead Water Company in the Valley of Stacy's Brook, Swampscott.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12580	July 18	None.	None.	0.0	48.50	.0074	.0012	11.46	.3500	.0022	.0462	17.0	.0120

Odor, none.—— The sample was collected from a pump drawing water from 72 tubular wells near the pumping station of the Marblehead Water Company in Swampscott. All the tubular wells in this vicinity were connected with the pump.

Microscopical Examination.

No organisms.

Chemical Examination of Water from Floating Bridge Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
12578	July 18	Decided, green.	Slight, green.	1.00	6.50	2.75	.0000	.0320	.0288	.0032	.99	.0020	.0000	.7507	1.9

Odor, distinctly disagreeable, becoming vegetable and grassy on heating.—— The sample was collected from the pond at the surface, near the northeasterly shore.

Microscopical Examination.

Diatomaceæ, *Melosira*, 62; *Synedra*, 1; *Tabellaria*, 216. Cyanophyceæ, *Anabæna*, 760; *Oscillaria*, 5. Algæ, *Arthrodesmus*, 6; *Closterium*, 160; *Staurastrum*, 64. Infusoria, *Dinobryon cases*, 3; *Peridinium*, 1; *Trachelomonas*, 1. Vermes, *Anuræa*, 2; *Monocerca*, 1; *Rotifer*, 1. Miscellaneous, *Zoöglœa*, 48. Total, 1,331.

WATER SUPPLY OF TAUNTON.

In the early part of April, 1894, the direct connection between the filter-basin and the Taunton River was shut off and water from Elder's Pond was discharged into the filter-basin and pumped thence for the supply of the city. In the latter part of May the use of the filter-basin was discontinued, the water of the Lakeville supply being discharged directly into the pump well at the pumping station, and during the remainder of the year all of the water supplied to the city was drawn from this source. The filter-basin is held in reserve for use in emergencies.

Beginning on April 10, water was pumped from Assawompsett Pond into Elder's Pond and a nearly constant level was maintained in the latter pond during the remainder of the year, the difference between the highest and lowest levels recorded being about 1.8 feet.

Chemical Examination of Water from Assawompsett Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11940	Mar. 26	Slight.	Slight.	0.55	3.10	1.15	.0000	.0148	.0126	.0022	.49	.0030	.0000	.5736	0.6
12286	May 28	V. slight.	Slight.	0.60	3.05	1.20	.0000	.0142	.0114	.0028	.43	.0030	.0000	.5655	0.6
12435	June 25	Slight.	Slight, green.	0.47	3.10	1.30	.0004	.0150	.0126	.0024	.49	.0000	.0000	.5174	0.5
12606	July 24	V. slight.	V. slight.	0.30	3.40	1.40	.0000	.0126	.0112	.0014	.53	.0000	.0000	.4273	0.8
12833	Aug. 27	Slight.	Slight.	0.20	3.80	1.70	.0000	.0146	.0132	.0014	.51	.0030	.0000	.3542	0.6
13055	Oct. 1	Slight, white.	Slight.	0.17	3.35	1.25	.0004	.0186	.0150	.0036	.58	.0020	.0000	.3752	0.5
13196	Oct. 23	Slight.	Slight, white.	0.15	3.25	1.20	.0000	.0168	.0146	.0022	.58	.0030	.0000	.3041	0.8
13399	Nov. 28	Slight.	Slight.	0.25	2.95	1.10	.0006	.0164	.0132	.0032	.51	.0030	.0000	.3936	0.6
13556	Dec. 28	Slight.	Cons.	0.30	2.95	1.00	.0012	.0182	.0150	.0032	.49	.0020	.0000	.3989	1.3
Av.	....	....	....	0.33	3.22	1.26	.0003	.0157	.0132	.0025	.51	.0021	.0000	.4344	0.7

Averages by Years.

-	1887*	-	-	0.45	3.63	1.57	.0005	.0180	-	-	.48	.0015	-	-	-
-	1888†	-	-	0.30	4.20	1.35	.0001	.0238	-	-	.45	.0030	.0001	-	-
-	1891‡	-	-	0.03	2.80	1.02	.0000	.0157	.0110	.0047	.46	.0025	.0000	-	0.4
-	1894	-	-	0.33	3.22	1.26	.0003	.0157	.0132	.0025	.51	.0021	.0000	.4344	0.7

* June and September. † January and May. ‡ December, two samples.

NOTE to analyses of 1894: Odor, in August and October, none; at other times, vegetable. —— The samples were collected from the pond at the intake of the Taunton Water Works.

TAUNTON.

Microscopical Examination of Water from Assawompsett Pond, Lakeville.

[Organisms per cubic centimeter.]

	1894.								
	Mar.	May.	July.	July.	Aug.	Oct.	Oct.	Nov.	Dec.
Day of examination,	28	28	2	26	29	2	24	30	31
Number of sample,	11940	12286	12435	12606	12833	13055	13196	13399	13556
PLANTS.									
Diatomaceæ,	**30**	**37**	**64**	**2**	**14**	**25**	**63**	**294**	**170**
Asterionella,	8	0	0	0	7	4	31	232	112
Cyclotella,	2	3	0	0	0	3	1	3	2
Melosira,	9	30	38	1	5	18	29	18	14
Synedra,	0	4	25	1	2	0	2	40	36
Tabellaria,	11	0	1	0	0	0	0	1	6
Cyanophyceæ,	**0**	**32**	**0**	**0**	**3**	**3**	**2**	**0**	**pr.**
Clathrocystis,	0	0	0	0	3	2	2	0	0
Microcystis,	0	32	0	0	0	1	0	0	pr.
Algæ,	**12**	**0**	**0**	**0**	**15**	**6**	**60**	**0**	**0**
Chlorococcus,	0	0	0	0	10	0	0	0	0
Hyalotheca,	0	0	0	0	5	6	0	0	0
Protococcus,	12	0	0	0	0	0	60	0	0
ANIMALS.									
Rhizopoda,	**0**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**pr.**
Difflugia,	0	0	0	0	1	0	0	0	pr.
Euglypha,	0	2	0	0	0	0	0	0	0
Infusoria,	**56**	**0**	**15**	**2**	**3**	**0**	**1**	**3**	**46**
Dinobryon,	5	0	0	0	0	0	0	0	4
Dinobryon cases,	50	0	0	0	0	0	0	0	40
Peridinium,	1	0	12	2	3	0	1	3	1
Trachelomonas,	0	0	3	pr.	0	0	0	0	1
Vermes, Polyarthra,	**pr.**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Miscellaneous, Zoöglœa,	**9**	**40**	**60**	**28**	**0**	**0**	**3**	**48**	**110**
TOTAL,	107	111	139	32	36	34	130	345	326

TAUNTON.

Chemical Examination of Water from Elder's Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11941	Mar. 26	Slight.	Slight.	0.02	2.35	0.75	.0000	.0136	.0120	.0016	.34	.0000	.0000	.1578	0.3
12090	Apr. 23	V. slight.	V. slight.	0.02	1.50	–	.0022	.0110	.0102	.0008	.40	.0030	.0000	.1382	0.2
12270	May 21	V. slight.	V. slight.	0.04	1.60	0.95	.0000	.0128	.0110	.0018	.39	.0030	.0000	.1443	0.5
12436	June 25	Slight.	Slight.	0.08	2.40	0.75	.0004	.0124	.0110	.0014	.40	.0000	.0001	.1663	0.5
12607	July 24	Slight.	Slight.	0.04	2.50	1.00	.0000	.0128	.0094	.0034	.44	.0000	.0000	.1617	0.5
12832	Aug. 27	V. slight.	Slight.	0.03	3.00	1.15	.0000	.0142	.0128	.0014	.42	.0030	.0000	.1617	0.3
13056	Oct. 1	V. slight.	V. slight.	0.03	2.60	0.75	.0000	.0148	.0126	.0022	.50	.0000	.0000	.2054	0.3
13197	Oct. 23	Slight.	V. slight.	0.03	2.55	1.25	.0000	.0154	.0138	.0016	.45	.0030	.0000	.1698	0.5
13400	Nov. 28	V. slight.	V. slight.	0.05	2.55	1.00	.0002	.0124	.0118	.0006	.44	.0030	.0000	.2091	0.5
13557	Dec. 28	V. slight.	Slight.	0.04	2.20	0.85	.0014	.0158	.0154	.0004	.45	.0000	.0000	.1540	0.8
Av.	....	....	....	0.04	2.32	0.94	.0004	.0135	.0120	.0015	.42	.0015	.0000	.1668	0.4

Averages by Years.

–	1887*	–	–	0.00	2.50	0.58	.0004	.0130	–	–	.41	.0030	–	–	–
–	1888†	–	–	0.05	2.00	0.45	.0000	.0138	–	–	.35	.0000	.0000	–	–
–	1891‡	–	–	0.00	2.03	0.90	.0000	.0143	.0120	.0023	.40	.0010	.0001	–	0.3
–	1894	–	–	0.04	2.32	0.94	.0004	.0135	.0120	.0015	.42	.0015	.0000	.1668	0.4

* September. † May. ‡ December, two samples.

NOTE to analyses of 1894: Odor, in April, June, July and October, none; at other times, vegetable. —— The samples were collected from the pond in the vicinity of the gate-house of the Taunton Water Works.

TAUNTON.

Microscopical Examination of Water from Elder's Pond, Lakeville.

[Number of organisms per cubic centimeter.]

	1894.									
	Mar.	Apr.	May.	July.	July.	Aug.	Oct.	Oct.	Nov.	Dec.
Day of examination,	28	24	24	2	26	29	2	25	30	31
Number of sample,	11941	12090	12270	12436	12607	12832	13056	13197	13400	13557
PLANTS.										
Diatomaceæ,	**3**	**3**	**9**	**5**	**2**	**17**	**35**	**11**	**16**	**33**
Asterionella,	0	0	0	0	0	13	31	4	16	33
Melosira,	0	0	0	0	0	0	0	5	0	0
Synedra,	pr.	1	8	5	0	4	2	2	0	pr.
Tabellaria,	3	2	1	0	2	0	2	0	0	0
Cyanophyceæ,	**0**	**0**	**1**	**6**	**14**	**12**	**44**	**36**	**1**	**pr.**
Aphanocapsa,	0	0	0	0	2	0	44	32	0	0
Chroöcoccus,	0	0	0	0	8	0	0	4	0	0
Microcystis,	0	0	1	6	4	12	0	0	1	pr.
Algæ,	**3**	**0**	**0**	**0**	**8**	**0**	**0**	**8**	**18**	**8**
Raphidium,	3	0	0	0	8	0	0	8	10	8
Tetraspora,	0	0	0	0	0	0	0	0	8	0
ANIMALS.										
Infusoria,	**28**	**7**	**8**	**4**	**6**	**6**	**0**	**2**	**51**	**10**
Cryptomonas,	0	2	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	1	0	0	0	0	7	0
Dinobryon cases,	28	5	0	0	0	4	0	0	44	10
Mallomonas,	0	0	0	1	0	0	0	1	0	0
Peridinium,	0	0	2	0	6	2	0	1	0	pr.
Trachelomonas,	0	0	0	2	pr.	0	0	0	0	0
Vorticella,	0	0	6	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	**6**	**1**	**44**	**9**	**26**	**11**	**0**	**52**	**0**	**0**
TOTAL,	40	11	62	24	56	46	79	109	86	51

TAUNTON.

Chemical Examination of Water from the Filter-basin of the Taunton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11685	Jan. 26	Slight.	Slight.	0.75	5.45	–	.0008	.0068	–	–	.63	.0200	.0000	.6991	1.4
11808	Feb. 26	V. slight.	Slight.	0.70	4.90	–	.0006	.0124	–	–	.53	.0120	.0000	.6464	1.3
11943	Mar. 26	V. slight.	Cons.	0.75	4.95	1.40	.0006	.0108	.0098	.0010	.56	.0120	.0000	.6275	0.6
12089	Apr. 23	Slight.	Slight.	0.40	4.35	1.50	.0008	.0136	.0112	.0024	.56	.0150	.0001	.4345	1.3
12287	May 28	Slight.	Slight.	0.08	2.75	0.90	.0004	.0164	.0108	.0056	.43	.0030	.0000	.1833	0.5
12434	June 25	Slight.	Slight.	0.04	4.15	1.25	.0036	.0140	.0104	.0036	.50	.0380	.0008	.1525	1.0
12605	July 24	Slight.	Slight, green.	0.07	4.65	1.20	.0000	.0134	.0098	.0036	.57	.0210	.0003	.1232	1.1
12835	Aug. 27	Distinct.	Slight.	0.07	4.70	–	.0000	.0182	.0118	.0064	.56	.0050	.0002	.0847	1.6
13058	Oct. 1	Distinct, green.	Slight, green.	0.10	4.10	1.25	.0000	.0116	.0070	.0046	.58	.0180	.0000	.1027	1.4
13199	Oct. 23	Slight.	Cons., gray.	0.05	3.95	1.05	.0008	.0124	.0066	.0058	.55	.0180	.0001	.1106	1.4
13401	Nov. 28	V. slight.	Slight.	0.08	3.75	0.95	.0014	.0108	.0086	.0022	.52	.0180	.0001	.1378	1.3
13559	Dec. 28	V. slight.	Slight.	0.05	3.90	0.95	.0004	.0108	.0092	.0016	.60	.0300	.0000	.1424	1.6
Av.	....	....	....	0.26	4.36	1.16	.0008	.0132*	.0095	.0037	.55	.0175	.0001	.2871	1.2

Averages by Years.

–	1887†	–	–	0.29	5.66	–	.0017	.0092	–	–	.60	.0167	–	–	–
–	1888	–	–	0.47	5.40	–	.0010	.0120	–	–	.53	.0150	.0001	–	–
–	1889	–	–	0.29	5.12	–	.0012	.0073	–	–	.57	.0185	.0001	–	–
–	1890	–	–	0.33	5.91	–	.0012	.0087	–	–	.57	.0227	.0001	–	1.9
–	1891	–	–	0.35	5.25	3.76	.0014	.0073	–	–	.55	.0212	.0000	–	1.7
–	1892	–	–	0.60	5.53	3.88	.0005	.0124	–	–	.58	.0147	.0001	–	1.6
–	1893	–	–	0.82	5.41	1.82	.0026	.0149	–	–	.57	.0114	.0001	.6763	1.4
–	1894	–	–	0.26	4.36	1.16	.0008	.0132	.0095	.0037	.55	.0175	.0001	.2871	1.2

* Exclusive of Nos. 11685 and 11808. † June to December.

NOTE to analyses of 1894: Iron, .0158. Odor, vegetable, sometimes mouldy or disagreeable.—— The first three samples were collected from a faucet at the pumping station, and the others directly from the filter-basin.

TAUNTON.

Microscopical Examination of Water from the Filter Basin of the Taunton Water Works.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	July.	July.	Aug.	Oct.	Oct.	Nov.	Dec.
Day of examination,	27	27	29	24	29	2	26	29	2	25	30	31
Number of sample,	11685	11808	11943	12089	12287	12434	12605	12835	13058	13199	13401	13589
PLANTS.												
Diatomaceæ,	**4**	**4**	**10**	**64**	**930**	**86**	**324**	**560**	**1,241**	**78**	**98**	**172**
Asterionella,	pr.	0	0	62	300	0	0	0	1,240	23	68	136
Melosira,	1	2	3	0	0	0	0	0	1	10	3	0
Navicula,	0	1	pr.	0	0	0	2	0	0	1	1	0
Synedra,	1	1	5	4	630	84	320	560	0	44	26	36
Tabellaria,	2	0	2	0	0	2	2	0	0	0	pr.	0
Cyanophyceæ,	**pr.**	**1**	**0**	**3**	**2**	**0**	**0**	**0**	**92**	**2**	**pr.**	**1**
Aphanocapsa,	0	0	0	0	0	0	0	0	92	0	0	0
Oscillaria,	pr.	1	0	3	2	0	0	0	pr.	2	pr.	1
Algæ,	**0**	**4**	**0**	**28**	**0**	**0**	**4**	**1**	**2**	**41**	**0**	**0**
Chlorococcus,	0	0	0	0	0	0	pr.	0	0	12	0	0
Protococcus,	0	0	0	28	0	0	0	0	0	24	0	0
Raphidium,	0	4	0	0	0	0	2	0	0	4	0	0
Scenedesmus,	0	0	0	0	0	0	2	1	2	1	0	0
Fungi, Crenothrix,	**0**	**32**	**5**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.												
Infusoria,	**1**	**pr.**	**22**	**50**	**966**	**17**	**46**	**2**	**47**	**1,081**	**24**	**2**
Cryptomonas,	0	0	0	13	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	34	840	0	0	0	32	41	0	0
Dinobryon cases,	1	0	22	0	120	0	0	0	15	1,040	24	0
Monas,	0	0	0	0	0	0	2	0	0	0	0	0
Peridinium,	0	pr.	0	0	5	17	44	2	0	0	pr.	2
Synura,	0	0	0	3	0	0	0	0	0	0	0	0
Vorticella,	pr.	0	0	0	1	0	0	0	0	0	0	0
Vermes,	**0**	**0**	**0**	**1**	**3**	**1**	**0**	**2**	**5**	**4**	**2**	**0**
Anurea,	0	0	0	0	pr.	0	0	0	pr.	1	0	0
Polyarthra,	0	0	0	0	3	0	0	1	2	1	0	0
Rotatorian ova,	0	0	0	1	0	0	0	0	3	2	1	0
Rotifer,	0	0	0	0	0	1	0	1	0	0	1	0
Miscellaneous, Zoöglœa,	**0**	**16**	**18**	**0**	**0**	**0**	**46**	**0**	**0**	**6**	**1**	**3**
TOTAL,	5	57	55	149	1,901	104	420	565	1,387	1,212	125	178

TAUNTON.

Chemical Examination of Water from the Taunton River, at Taunton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11684	Jan. 26	Slight.	Cons.	1.10	5.10	2.25	.0006	.0112	.0090	.0022	.61	.0070	.0001	.9346	1.3
11807	Feb. 26	V. slight.	Slight.	1.20	4.55	2.05	.0000	.0208	.0186	.0022	.53	.0050	.0001	1.1080	0.8
11942	Mar. 26	Slight.	Cons.	1.40	4.85	2.40	.0008	.0188	.0168	.0020	.50	.0070	.0001	1.1896	0.7
12143	May 2	Slight.	Cons., rusty.	1.60	4.35	2.10	.0048	.0262	.0236	.0026	.56	.0050	.0001	1.1760	0.6
12269	May 21	V. slight.	Cons.	1.60	4.35	2.35	.0042	.0254	.0234	.0020	.49	.0030	.0001	.9633	1.3
12433	June 25	V. slight.	Slight.	2.20	5.45	2.70	.0052	.0246	.0230	.0016	.53	.0000	.0001	1.1858	1.1
12604	July 24	Slight.	Slight.	1.20	4.50	1.65	.0020	.0220	.0208	.0012	.64	.0020	.0001	.6737	0.9
12834	Aug. 27	V. slight.	Slight.	0.70	5.10	1.60	.0078	.0168	.0152	.0016	.70	.0050	.0000	.4581	1.1
13057	Oct. 1	Slight.	Slight.	0.70	5.45	1.80	.0024	.0206	.0170	.0036	.72	.0020	.0001	.6122	1.4
13198	Oct. 23	Slight.	Cons.	1.10	6.30	2.55	.0004	.0230	.0194	.0036	.75	.0050	.0002	.9203	1.6
13484	Dec. 14	Slight.	Slight.	1.35	5.75	2.45	.0022	.0240	.0216	.0024	.65	.0120	.0000	1.0664	1.3
13558	Dec. 28	Decided.	Heavy, rusty.	1.20	4.35	1.95	.0024	.0350	.0192	.0158	.47	.0030	.0001	.9586	0.9
Av.	....	....	....	1.28	5.01	2.15	.0027	.0224	.0190	.0034	.60	.0047	.0001	.9372	1.1

Averages by Years.

-	1887*	-	-	1.29	5.84	2.09	.0030	.0285	-	-	.59	.0097	-	-	-
-	1888	-	-	1.51	5.25	2.28	.0015	.0294	-	-	.44	.0086	.0001	-	-
-	1889	-	-	1.67	4.50	2.17	.0015	.0304	.0270	.0034	.45	.0085	.0001	-	-
-	1890	-	-	1.31	5.36	2.27	.0016	.0254	.0225	.0029	.48	.0118	.0001	-	1.3
-	1891	-	-	1.12	4.77	1.98	.0006	.0220	.0197	.0023	.47	.0095	.0001	-	1.0
-	1892	-	-	1.08	5.27	2.20	.0012	.0225	.0198	.0027	.54	.0093	.0001	-	1.1
-	1893	-	-	1.38	5.33	2.31	.0043	.0246	.0212	.0034	.56	.0078	.0002	1.0820	1.1
-	1894	-	-	1.28	5.01	2.15	.0027	.0224	.0190	.0034	.60	.0047	.0001	.9372	1.1

* June to December.

NOTE to analyses of 1894: Odor, vegetable, sometimes also mouldy. —— The samples were collected from the river opposite the filter-basin of the Taunton Water Works.

Microscopical Examination.

The average number of organisms found in these samples was 374.

TISBURY.

Water Supply of Tisbury. — Vineyard Haven Water Company.

Chemical Examination of Water from the Filter-gallery, at Tashmoo Spring.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
12610	July 25	None.	None.	0.01	4.10	.0004	.0000	0.98	.0070	.0000	.0007	0.5	.0100
12819	Aug. 25	None.	None.	0.00	5.50	.0000	.0004	1.00	.0020	.0000	.0000	0.8	.0030

Odor, none. —— The samples were collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No organisms.

Uxbridge.

For analyses of samples of water from Mendon Pond, see Mendon.

Water Supply of Wakefield and Stoneham. — Wakefield Water Company.

Chemical Examination of Water from Crystal Lake, Wakefield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation. Total.	Loss on Ignition.	Ammonia. Free.	Albuminoid. Total.	Dis-solved.	Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11889	Mar. 14	Slight.	Cons.	0.08	3.95	1.35	.0008	.0142	.0122	.0020	.63	.0300	.0001	.2184	1.6
12371	June 13	V. slight.	Slight.	0.18	4.45	1.30	.0010	.0140	.0132	.0008	.64	.0050	.0001	.2872	1.8
12922	Sept. 11	Distinct.	Slight.	0.23	4.85	1.40	.0002	.0170	.0138	.0032	.64	.0000	.0000	.2387	1.8
13480	Dec. 13	V. slight.	Slight.	0.15	4.30	1.00	.0024	.0166	.0152	.0014	.77	.0070	.0000	.2040	1.8
Av.	....	....	....	0.16	4.39	1.26	.0011	.0155	.0136	.0019	.67	.0105	.0001	.2371	1.8

Averages by Years.

-	1887*	-	-	0.17	3.73	0.91	.0006	.0174	-	-	.51	.0043	-	-	-
-	1888†	-	-	0.13	3.69	0.92	.0009	.0167	-	-	.48	.0080	.0001	-	-
-	1889‡	-	-	0.10	3.60	0.87	.0009	.0141	.0119	.0022	.49	.0163	.0002	-	-
-	1890§	-	-	0.25	4.22	1.35	.0001	.0371	.0190	.0181	.46	.0090	.0001	-	1.8
-	1891‖	-	-	0.08	4.17	1.50	.0003	.0160	.0129	.0031	.47	.0145	.0001	-	1.6
-	1893	-	-	0.14	3.81	1.27	.0028	.0164	.0141	.0023	.57	.0108	.0001	.2638	1.5
-	1894	-	-	0.16	4.39	1.26	.0011	.0155	.0136	.0019	.67	.0105	.0001	.2371	1.8

* June to December. † January to October. ‡ January, March and June.
§ Three in October. ‖ May and November.

NOTE to analyses of 1894: Odor, in September, distinctly disagreeable, becoming vegetable on heating; at other times distinctly vegetable. —— The samples were collected from a faucet.

WAKEFIELD AND STONEHAM.

Microscopical Examination of Water from Crystal Lake, Wakefield.

[Number of organisms per cubic centimeter.]

	1894.			
	March.	June.	Sept.	Dec.
Day of examination,	15	14	13	15
Number of sample,	11889	12371	12922	13480
PLANTS.				
Diatomaceæ,	**147**	**65**	**226**	**5**
Asterionella,	140	0	204	0
Cyclotella,	5	60	1	1
Fragilaria,	0	5	16	0
Tabellaria,	2	0	5	4
Cyanophyceæ,	**0**	**12**	**2**	**0**
Anabæna,	0	2	0	0
Chlorococcus,	0	10	0	0
Microcystis,	0	0	2	0
Algæ,	**0**	**222**	**133**	**0**
Protococcus,	0	200	65	0
Raphidium,	0	18	24	0
Staurogenia,	0	4	0	0
Tetraspora,	0	0	44	0
Fungi, Crenothrix,	**0**	**0**	**3**	**0**
ANIMALS.				
Rhizopoda, Euglypha,	**0**	**0**	**1**	**0**
Infusoria,	**1**	**3**	**86**	**0**
Ceratium,	0	0	1	0
Dinobryon,	1	0	0	0
Dinobryon cases,	0	0	84	0
Mallomonas,	0	3	0	0
Peridinium,	0	0	1	0
Miscellaneous, Zoöglœa,	**15**	**0**	**15**	**76**
TOTAL,	163	302	466	81

The following table contains analyses of samples of water from test wells driven in the northerly part of Wakefield in order to determine the feasibility of obtaining an additional water supply for either the city of Lynn or the town of Wakefield from the ground in this portion of the town. The first six samples were from wells driven north of Lowell Street in sandy land which adjoins an extensive swamp upon the Saugus River; the seventh from a well on the northerly side of the Saugus River, about 3,000 feet below Lake Quannapowitt, and the last from a well at the northerly end of the lake. The exact location of the first six wells is shown upon a plan in the office of the State Board of Health, and the numbers of the

WAKEFIELD AND STONEHAM.

wells as given in the first column of the table correspond to the numbers as given upon this plan. The depths at which the samples were taken were as follows: No. 8, 60.2 feet; No. 4, 47.7 feet; No. 9, 37.8 feet; No. 2, 36.2 feet; No. 1, 49.0 feet; No. 12, 35.8 feet; No. 16, 26.2 feet; No. 17, 80.9 feet.

These tests are referred to at considerable length in the report of the State Board of Health upon a Metropolitan Water Supply, pages 31, 32, 47 and 48.

[Parts per 100,000.]

Number of Well.	Number of Sample.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
		1894.												
8	12311	June 4	Decided, clayey.	Cons., earthy.	0.60	10.95	.0006	.0056	.39	.0030	.0000	.2695	7.7	.0825
4	12332	June 7	Decided, clayey.	Cons., earthy.	0.08	8.50	.0006	.0014	.33	.0000	.0000	.0470	6.4	.0020
9	12378	June 14	Decided, clayey.	Heavy, sandy.	0.05*	8.05*	.0004	.0000	.82	.0480	.0001	.0331	4.3	.0100
2	12382	June 16	Distinct, clayey.	Slight, earthy.	0.02*	8.15*	.0000	.0000	.54	.0350	.0000	.0192	5.0	.0045*
1	12441	June 20	Distinct, clayey.	Cons., sandy.	0.00*	7.70*	.0014	.0000	.34	.0000	.0003	.0277	5.0	.0000*
12	12464	July 2	Thick, clayey.	Heavy, clayey.	0.05*	14.60*	.0070	.0018	.60	.0000	.0001	.1386	10.0	.0600*
16	12528	July 12	Slight, milky.	Slight, sandy.	0.15*	7.20	.0012	.0002	.30	.0020	.0000	.0539	3.2	.0400
17	12537	July 14	Distinct, clayey.	Cons., sandy.	0.05*	14.50*	.0350	.0028	.46	.0000	.0002	.1147	6.1	.0500

* These determinations were made on water which had been filtered through filter paper.

Odor of Nos. 12378 and 12464, earthy; of the other samples, none. On heating, a faintly earthy odor was developed in Nos. 12311 and 12382.

Microscopical Examination.

No. 12528. Fungi, *Crenothrix*, 24.
No organisms were found in the other samples.

Water Supply of Waltham.

During the year 1894 the water of the well and filter-basin has been almost entirely free from the microscopic organisms which were present at times in abundance previous to the covering of the well and filter-basin in the latter part of 1893. From June 19 to September 1 the pumps were run continuously, excepting occasionally at night, and very little water was pumped into or drawn from the open distributing reservoir. The water of the reservoir has contained on an average a higher albuminoid ammonia than in any previous year since the examinations were begun, as shown by the table of averages by years on page 330, and very large numbers of

organisms have been found in the water, especially of *Asterionella*, an organism which was present in great abundance in the earlier portion of the year.

Chemical Examination of Water from the Well and Filter-basin of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11613	Jan. 9	None.	None.	0.00	6.95	.0018	.0010	.49	.0200	.0000	.0468	3.0	.0040
11729	Feb. 7	None.	V. slight.	0.00	6.80	.0020	.0024	.51	.0150	.0000	.0640	3.0	.0025
11856	Mar. 7	None.	Slight, earthy.	0.00	6.35	.0036	.0022	.48	.0120	.0000	.0680	3.0	.0050
12091	Apr. 23	None.	Slight, sandy.	0.02	6.20	.0032	.0012	.52	.0350	.0000	.0632	3.0	.0050
12170	May 8	V. slight.	V. slight.	0.00	5.90	.0018	.0028	.51	.0250	.0000	.1025	2.7	.0000
12341	June 11	None.	Slight, black.	0.03	6.35	.0020	.0018	.48	.0220	.0000	.0608	2.9	.0080
12526	July 12	None.	None.	0.02	7.30	.0034	.0020	.53	.0130	.0000	.0654	3.0	.0060
12731	Aug. 13	None.	None.	0.05	6.70	.0036	.0022	.46	.0080	.0000	.0500	3.2	.0040
12970	Sept. 17	None.	None.	0.02	7.50	.0032	.0010	.53	.0250	.0000	.0400	3.2	.0050
13140	Oct. 16	None.	Slight.	0.04	7.30	.0030	.0030	.52	.0100	.0000	.0450	3.6	.0050
13325	Nov. 19	None.	None.	0.01	7.10	.0026	.0020	.54	.0200	.0000	.0468	3.5	.0035
13494	Dec. 17	None.	None.	0.02	6.60	.0034	.0018	.54	.0250	.0000	.0770	3.4	.0050
Av.	....	....	....	0.02	6.75	.0028	.0019	.51	.0192	.0000	.0608	3.1	.0044

Averages by Years.

-	1887*	-	-	.00	6.71	.0007	.0038	.47	.0250	-	-	-	-
-	1888	-	-	.00	6.70	.0009	.0054	.46	.0273	.0003	-	-	-
-	1889†	-	-	.00	6.43	.0006	.0034	.48	.0378	.0002	-	-	-
-	1890‡	-	-	.00	-	.0000	.0012	.47	.0380	.0002	-	-	-
-	1892	-	-	.00	6.81	.0033	.0027	.45	.0162	.0000	-	3.4	-
-	1893	-	-	.01	6.86	.0036	.0022	.47	.0179	.0000	.0643	3.4	.0020
-	1894	-	-	.02	6.75	.0028	.0019	.51	.0192	.0000	.0608	3.1	.0044

* June to December. † January to May. ‡ July.

NOTE to analyses of 1894: Odor, in January, faintly earthy; in May, very faintly vegetable; at other times, none.—— The first sample was collected from a faucet at the pumping station and the others from the filter-basin.

WALTHAM.

Microscopical Examination of Water from the Well and Filter-basin of the Waltham Water Works.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	10	8	8	24	9	13	12	14	18	17	21	18
Number of sample,	11613	11729	11856	12091	12170	12341	12526	12731	12970	13140	13325	13494
PLANTS.												
Diatomaceæ, Melosira,	6	4	0	0	0	0	0	0	0	0	0	0
Fungi, Crenothrix,	0	0	0	1	0	0	0	0	0	17	0	1
TOTAL,	6	4	0	1	0	0	0	0	0	17	0	1

Chemical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11612	Jan. 9	Decided.	Heavy, green.	0.01	6.95	.0000	.0108	.49	.0030	.0000	.1053	3.0	.0020
11730	Feb. 7	Decided, green.	Cons., yellow.	0.00	6.95	.0002	.0136	.49	.0070	.0002	.1264	3.0	.0025
11855	March 7	Distinct.	Heavy, green.	0.02	5.95	.0008	.0192	.48	.0070	.0000	.0664	3.0	.0025
12047	April 16	V. slight.	Cons., green.	0.02	5.70	.0000	.0172	.50	.0050	.0001	.0816	2.9	.0010
12169	May 8	Decided.	Cons., yellow.	0.01	6.35	.0000	.0122	.53	.0070	.0001	.1271	2.9	.0025
12340	June 11	Decided.	Slight.	0.02	7.10	.0028	.0140	.50	.0050	.0001	.1039	2.9	.0080
12527	July 12	Distinct, green.	Slight, green.	0.00	6.05	.0012	.0130	.56	.0000	.0000	.1078	3.0	-
12732	Aug. 13	Decided, green.	Slight, green.	0.08	7.80	.0016	.0158	.46	.0300	.0000	.0639	3.3	.0040
12971	Sept. 17	Slight.	None.	0.03	7.20	.0000	.0138	.54	.0000	.0000	.0693	3.1	.0050
13141	Oct. 16	Slight.	Slight.	0.04	7.70	.0000	.0192	.52	.0000	.0000	.0829	3.5	.0020
13326	Nov. 19	None.	V. slight.	0.02	7.15	.0000	.0122	.54	.0120	.0000	.1092	3.1	.0025
13495	Dec. 17	V. slight.	V. slight.	0.07	6.70	.0016	.0070	.55	.0180	.0001	.0678	3.4	.0030
Av.	....	....	....	0.03	6.80	.0007	.0140	.51	.0078	.0001	.0926	3.1	.0032

Averages by Years.

-	1887*	-	-	.00	6.66	.0007	.0061	.46	.0197	-	-	-	-
-	1888	-	-	.00	6.45	.0003	.0075	.46	.0248	.0003	-	-	-
-	1889†	-	-	.00	6.21	.0003	.0078	.47	.0280	.0003	-	-	-
-	1890‡	-	-	.00	-	.0000	.0124	.47	.0280	.0001	-	-	-
-	1891§	-	-	.00	6.25	.0000	.0044	.40	.0200	.0000	-	3.0	-
-	1892	-	-	.01	6.28	.0006	.0082	.44	.0119	.0001	-	3.0	-
-	1893	-	-	.04	6.72	.0006	.0074	.47	.0127	.0001	.1033	3.1	.0019
-	1894	-	-	.03	6.80	.0007	.0140	.51	.0078	.0001	.0926	3.1	.0032

* June to December. † January to May. ‡ February. § May.

NOTE to analyses of 1894: Odor, generally faintly aromatic, sometimes disagreeable or none. The odor is generally stronger on heating. —— The samples were collected from the reservoir.

WALTHAM.

Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	10	8	8	17	9	13	12	14	18	17	21	18
Number of sample,	11612	11730	11855	12047	12169	12340	12527	12732	12971	13141	13326	13495
PLANTS.												
Diatomaceæ,	**20,226**	**23,416**	**40,000**	**63,000**	**50,100**	**4,200**	**2,320**	**88**	**9**	**32**	**1**	**4**
Asterionella,	20,000	23,360	40,000	63,000	50,000	2,000	0	0	0	0	1	0
Synedra,	2	0	0	0	100	2,200	2,320	88	9	32	0	4
Tabellaria,	224	56	0	0	0	0	0	0	0	0	0	0
Fungi, Leptothrix,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**800**	**820**	**1,320**	**1,780**
ANIMALS.												
Infusoria,	**0**	**26**	**0**	**0**	**150**	**450**	**3**	**9**	**440**	**0**	**3**	**0**
Cryptomonas,	0	0	0	0	50	150	0	0	0	0	0	0
Dinobryon,	0	20	0	0	50	0	0	0	0	0	0	0
Monas,	0	4	0	0	50	300	0	0	0	0	0	0
Peridinium,	0	0	0	0	0	0	3	9	440	0	3	0
Vorticella,	0	2	0	0	0	0	0	0	0	0	0	0
Vermes, Rotifer,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**
Miscellaneous, Zoöglœa,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**92**	**0**	**0**
TOTAL,	20,226	23,442	40,000	63,000	50,250	4,650	2,323	99	1,249	944	1,324	1,784

Chemical Examination of Water from Charles River, at Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13225	Oct. 30	V. slight.	Slight.	0.58	6.15	1.55	.0030	.0192	.0170	.0022	.61	.0080	.0001	.4928	1.9

Odor, distinctly vegetable, becoming musty on heating. —— The sample was collected from the river, near the pumping station of the Waltham Water Works.

Microscopical Examination.

Ditaomaceæ, *Cymbella*, 1; *Diatoma*, 1; *Pinnularia*, 1; *Synedra*, 3. Algæ, *Closterium*, 1. Fungi, *Crenothrix*, 176. Vermes, *Rotifer*, 1. Miscellaneous, *Zoöglœa*, 52. Total, 236.

WARE.

Water Supply of Ware.

There has been a great reduction in the amount of residue on evaporation, chlorine and nitrates in the water of this supply, as will be seen by an examination of the table of averages by years which follows. The main well, which was formerly the only source of supply of the town, is now supplemented by water from a spring and system of tubular wells, a description of which was given in the annual report for 1893. The water of the new wells and spring, as indicated by the analyses of samples collected in 1893 and 1894, contains a small amount of residue, chlorine and nitrates when compared with the water formerly drawn from the main well.

Chemical Examination of Water from the Main Well of the Ware Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11672	Jan. 23	None.	None.	0.0	4.70	.0014	.0004	.23	.1000	.0000	.0000	2.1	.0000
12443	June 28	None.	None.	0.0	5.25	.0028	.0014	.31	.1100	.0000	.0077	2.1	.0020
13205	Oct. 24	None.	None.	0.0	5.80	.0000	.0000	.26	.0900	.0000	.0118	1.8	.0010
Av.	....	....	....	0.0	5.25	.0014	.0006	.27	.1000	.0000	.0065	2.0	.0010

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
-	1887*	-	-	0.0	7.05	.0001	.0011	0.50	.2663	-	-	-	-
-	1888	-	-	0.0	7.58	.0000	.0011	1.36	.3262	.0002	-	-	-
-	1889†	-	-	0.0	8.14	.0001	.0013	0.89	.3111	.0000	-	-	-
-	1890‡	-	-	0.0	-	.0002	.0014	0.95	.3400	.0000	-	-	-
-	1891§	-	-	0.0	11.70	.0000	.0000	1.44	.7000	.0000	-	3.9	-
-	1892‖	-	-	0.0	10.53	.0000	.0008	1.15	.5666	.0000	-	3.8	-
-	1893¶	-	-	0.0	11.08	.0002	.0015	1.04	.4750	.0000	.0447	3.7	.0035
-	1894	-	-	0.0	5.25	.0014	.0006	.27	.1000	.0000	.0065	2.0	.0010

* June to November. † January to June. ‡ February.
§ November. ‖ February, July and December. ¶ February and August.

Note to analyses of 1894: Odor, none. —— The samples were collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No. 12443. Miscellaneous, *Zoöglœa*, 2.
No organisms were found in the other samples.

WARE.

Chemical Examination of Water from the Tubular Wells and Spring of the Ware Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12442	June 28	V. slight.	V. slight.	0.0	5.25	.0010	.0036	.25	.0780	.0000	.0000	2.2	.0115

Odor, none. —— The sample was collected from a 12-inch pipe, which conveys water from the tubular wells and spring into the main well.

Microscopical Examination.

No organisms.

Water Supply of Onset Bay Fire District, Wareham. — Onset Water Company.

The works are owned by the Onset Water Company, and water was introduced July 27, 1894. The source of supply is Sturtevant's also known as Jonathan's Pond, located in the westerly part of the town. It is said to have an area of about 16 acres and a maximum depth of about 25 feet. On account of the sandy character of the territory in which the pond is situated the limits of the drainage area are not well defined. Water is pumped to the distributing system, in connection with which there is an iron tank 20 feet in diameter and 40 feet in height, supported on a wooden trestle 60 feet in height. Distributing mains are of cast iron, service pipes of galvanized iron.

The advice of the State Board of Health to the Onset Water Company, with reference to the use of Sturtevant's or Jonathan's Pond as a source of water supply, may be found on page 42 of this volume. Analyses of samples of water from the pond and from a faucet supplied from the pond follow.

WAREHAM.

Chemical Examination of Water from Jonathan's Pond, Wareham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12288	May 28	None.	V. slight.	0.03	2.25	0.90	.0000	.0092	.0082	.0010	.60	.0000	.0000	.1092	0.0
13375	Nov. 26	V. slight.	V. slight.	0.05	2.10	0.40	.0004	.0088	.0074	.0014	.68	.0000	.0000	.1082	0.2
13560	Dec. 31	None.	V. slight.	0.02	1.95	0.55	.0004	.0132	.0120	.0012	.70	.0000	.0000	.1193	0.3
Av.	....	....	....	0.03	2.10	0.62	.0003	.0104	.0092	.0012	.66	.0000	.0000	.1122	0.2

Odor of the first sample, none; of the second, distinctly musty; of the last, faintly vegetable. —— No. 13375 was collected from a faucet about a mile from the pond, and the others from the pond.

Microscopical Examination of Water from Jonathan's Pond, Wareham.

[Number of organisms per cubic centimeter.]

	1894.		1895.
	June.	November.	January.
Day of examination,	29	27	2
Number of sample,	12288	13375	13560
PLANTS.			
Diatomaceæ, Tabellaria,	0	0	3
Algæ,	62	0	2
Dictyosphærium,	0	0	2
Protococcus,	62	0	0
Fungi, Crenothrix,	0	0	2
ANIMALS.			
Infusoria, Peridinium,	2	0	0
Miscellaneous, Zoöglœa,	0	56	2
Total,	64	56	9

Water Supply of Watertown and Belmont. — Watertown Water Supply Company.

The advice of the State Board of Health to the Watertown Water Supply Company, relative to certain proposed plans for filtering the public water supply of these towns, may be found on pages 42–44 of

WATERTOWN AND BELMONT.

this volume. A statement with regard to investigations made in connection with this application may be found on page 311 of the annual report of the Board for 1893, and analyses of samples of water collected in connection with the investigations may be found on pages 314 and 315 of the same report.

Chemical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11597	Jan. 3	None.	V. slight.	0.04	8.80	.0028	.0034	.66	.0700	.0000	.1053	3.6	.0180
11766	Feb. 13	None.	None.	0.02	8.90	.0024	.0036	.64	.0680	.0000	.0960	3.6	.0220
11871	Mar. 7	None.	None.	0.02	6.65	.0012	.0058	.52	.0900	.0000	.1464	3.0	.0175
12012	Apr. 9	None.	V. slight.	0.02	7.85	.0008	.0058	.60	.0600	.0000	.1080	3.1	.0115
12238	May 16	V. slight.	Slight.	0.12	9.60	.0006	.0056	.52	.0400	.0000	.1248	3.2	.0500
12370	June 13	Distinct, milky.	Cons., rusty.	0.20	8.90	.0002	.0080	.62	.0500	.0001	.1270	4.0	.0785
12521	July 11	Distinct, milky.	Slight, rusty.	0.08	8.60	.0066	.0066	.71	.0380	.0003	.1578	3.8	.0950
12753	Aug. 13	Decided, milky.	Cons., rusty.	0.20	9.70	.0118	.0062	.80	.0250	.0001	.1463	4.0	.0950
12986	Sept. 17	Slight, milky.	Cons., rusty.	0.35	8.50	.0154	.0076	.92	.0230	.0000	.1771	4.2	.0750
13135	Oct. 15	Slight, milky.	Slight.	0.18	8.10	.0092	.0056	.89	.0400	.0001	.1051	4.3	.0470
13343	Nov. 19	Slight.	Cons., rusty.	0.05	10.50	.0056	.0052	.85	.0580	.0001	.1365	4.0	.0920
13505	Dec. 17	None.	V. slight.	0.02	9.70	.0014	.0020	.67	.0880	.0000	.0385	4.3	.0180
Av.	....	....	....	0.11	8.82	.0048	.0054	.70	.0542	.0001	.1224	3.8	.0516

Averages by Years.

-	1887*	-	-	.00	7.09	.0005	.0034	.65	.0300	-	-	-	-
-	1888	-	-	.00	7.22	.0000	.0040	.63	.0647	.0000	-	-	-
-	1889†	-	-	.00	6.45	.0000	.0027	.64	.0642	.0000	-	-	-
-	1890‡	-	-	.00	7.40	.0014	.0042	.69	.0450	.0000	-	3.9	-
-	1892§	-	-	.07	7.90	.0041	.0046	.66	.0370	.0001	-	4.0	.0396
-	1893	-	-	.19	7.95	.0063	.0061	.66	.0489	.0001	.1275	3.5	.0315
-	1894	-	-	.11	8.82	.0048	.0054	.70	.0542	.0001	.1224	3.8	.0516

* June to December. † January to May. ‡ August. § September to December.

NOTE to analyses of 1894: Odor, generally none; in July, faintly mouldy, and in August and September, distinctly vegetable and mouldy. —— The samples were collected from a faucet at the pumping station.

WATERTOWN AND BELMONT.

Microscopical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Supply Company.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	5	15	13	11	19	14	12	16	20	17	22	20
Number of sample,	11597	11766	11871	12012	12238	12370	12521	12753	12986	13135	13343	13505
PLANTS.												
Fungi,	**24**	**0**	**2**	**14**	**360**	**1,320**	**1,860**	**372**	**148**	**26**	**268**	**152**
Cladothrix,	0	0	0	0	0	0	20	0	0	0	0	0
Crenothrix,	24	0	2	14	360	1,320	1,840	372	148	26	268	152
Miscellaneous, Zoöglœa,	**0**	**0**	**0**	**0**	**142**	**280**	**0**	**212**	**204**	**280**	**144**	**0**
TOTAL,	24	0	2	14	502	1,600	1,860	584	352	306	412	152

Chemical Examination of Water from a Faucet in Watertown, supplied from the Works of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1894.												
11642	Jan. 16	None.	V. slight.	0.05	9.70	.0000	.0032	.66	.0700	.0000	.0694	5.9	.0110
11727	Feb. 7	None.	None.	0.02	9.00	.0002	.0046	.64	.0800	.0000	.0960	4.2	.0100
11896	Mar. 14	None.	None.	0.02	8.20	.0006	.0072	.52	.1100	.0000	.1080	4.3	.0100
12076	Apr. 19	None.	None.	0.03	8.90	.0002	.0032	.60	.0700	.0000	.0908	3.9	.0100
12236	May 15	None.	None.	0.45	8.20	.0000	.0034	.57	.0480	.0000	.0998	3.8	.0100
12394	June 19	Distinct, milky.	None.	0.10	8.85	.0000	.0026	.59	.0350	.0001	.1024	3.9	.0170
12577	July 18	Distinct, milky.	Slight.	0.20	9.50	.0002	.0044	.72	.0300	.0001	.1617	4.3	.0300
12653	Aug. 3	Distinct, milky.	Slight, rusty.	0.10	9.20	.0000	.0046	.70	.0090	.0000	.0847	4.6	.0390
12964	Sept. 17	Slight, milky.	None.	0.12	10.00	.0002	.0038	.90	.0300	.0000	.1309	4.9	.0200
13102	Oct. 8	None.	None.	0.05	10.60	.0000	.0046	.90	.0180	.0001	.0608	5.3	.0100
13282	Nov. 7	V. slight.	None.	0.04	9.50	.0000	.0058	.87	.0250	.0000	.0885	5.0	.0190
13441	Dec. 5	None.	V. slight.	0.10	10.20	.0000	.0036	.80	.0630	.0000	.0785	5.4	.0260
Av.	1894.	....	....	0.11	9.32	.0001	.0042	.71	.0490	.0000	.0976	4.6	.0177
Av.	1893.	....	....	0.09	8.06	.0012	.0052	.61	.0426	.0001	.1322	3.7	.0165

Odor, generally none; in July and August, faintly vegetable, and in October, faintly unpleasant. —— The samples were collected from a faucet in a house in the easterly part of Watertown.

WATERTOWN AND BELMONT.

Microscopical Examination of Water from a Faucet in Watertown, supplied from the Works of the Watertown Water Supply Company.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	18	8	15	24	19	22	19	4	18	10	10	7
Number of sample,	11642	11727	11896	12076	12236	12394	12577	12653	12964	13102	13282	13441
PLANTS.												
Fungi, Crenothrix,	0	0	0	4	24	6	44	3	pr.	2	0	0
ANIMALS.												
Infusoria, Peridinium,	0	0	0	0	0	pr.	0	20	0	0	0	0
Miscellaneous, Zoöglœa,	0	0	0	0	24	82	0	260	4	1	0	0
TOTAL,	0	0	0	4	48	88	44	283	4	3	0	0

Chemical Examination of Water from a Faucet in Belmont, supplied from the Works of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
12171	1894. May 7	Decided, rusty.	Cons., rusty.	0.05	7.50	.0056	.0034	.61	.0000	.0001	.1132	3.4	.6000

Odor, distinctly mouldy. —— The sample was collected from a faucet in Belmont, 4 miles from the pumping station, and on 1 mile of dead end.

Microscopical Examination.

No organisms.

WAYLAND.

Water Supply of Wayland.

Chemical Examination of Water from the Filter-gallery of the Wayland Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11804	Feb. 21	Distinct.	Cons., fibrous.	0.30	4.90	.0076	.0078	.43	.0400	.0000	.2760	1.8	.0800
12239	May 17	Decided, clayey.	Cons., rusty.	0.40	4.40	.0080	.0092	.26	.0030	.0000	.3315	1.3	.1400
12808	Aug. 22	Decided.	V.heavy, rusty.	0.20	5.60	.0192	.0138	.30	.0020	.0001	.2772	1.7	.4300
13371	Nov. 22	Distinct.	Cons., fibrous.	0.30	4.45	.0142	.0296	.37	.0210	.0000	.3338	2.1	.0580
Av.	....	....	....	0.30	4.84	.0122	.0151	.34	.0165	.0000	.3046	1.7	.1770

Odor of the first sample, distinctly vegetable; of the others, none, becoming vegetable, and in May and November, also unpleasant on heating. —— The first three samples were collected from a faucet in the gate-house; the last sample was collected from the filter-gallery.

Microscopical Examination of Water from the Filter-gallery of the Wayland Water Works.

[Number of organisms per cubic centimeter.]

	1894.			
	February.	May.	August.	November.
Day of examination,	26	19	28	23
Number of sample,	11804	12239	12808	13371
PLANTS.				
Diatomaceæ, Melosira,	0	66	0	0
Fungi, Crenothrix,	10,800	12,400	132,000	13,400
ANIMALS.				
Infusoria,	0	2	0	50
Dinobryon cases,	0	1	0	0
Monas,	0	1	0	50
Total,	10,800	12,468	132,000	13,450

Water Supply of Webster.

Chemical Examination of Water from the Well of the Webster Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11777	Feb. 15	None.	V. slight.	0.00	3.25	.0002	.0008	.22	.0090	.0000	.0080	1.4	.0020
11905	Mar. 16	None.	V. slight.	0.00	3.15	.0008	.0010	.20	.0280	.0000	.0216	1.1	.0000
12069	Apr. 17	None.	None.	0.00	3.35	.0000	.0008	.21	.0220	.0000	.0078	1.3	.0000
12243	May 19	None.	V. slight.	0.00	3.30	.0000	.0006	.19	.0200	.0000	.0312	1.4	.0000
12387	June 18	None.	None.	0.00	3.40	.0000	.0000	.21	.0350	.0000	.0216	1.6	.0050
12554	July 16	None.	V. slight.	0.03	3.50	.0000	.0000	.24	.0200	.0000	.0000	1.6	.0050
12782	Aug. 18	None.	None.	0.02	3.30	.0000	.0000	.20	.0200	.0000	.0000	1.6	.0100
12989	Sept. 18	None.	None.	0.02	3.50	.0000	.0008	.21	.0280	.0000	.0038	1.3	.0000
13172	Oct. 18	None.	None.	0.02	4.00	.0000	.0014	.24	.0350	.0000	.0197	1.3	.0010
13335	Nov. 19	None.	V. slight.	0.00	3.70	.0000	.0010	.22	.0200	.0000	.0000	1.4	.0070
13550	Dec. 26	None.	None.	0.00	3.30	.0000	.0004	.20	.0180	.0000	.0000	1.4	.0050
Av.	....	....	....	0.01	3.43	.0001	.0006	.21	.0232	.0000	.0103	1.4	.0032

Odor in March and May, vegetable; at other times, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

No organisms.

Water Supply of Wellesley.

Chemical Examination of Water from the Filter-gallery of the Wellesley Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12427	June 25	None.	V. slight.	0.05	5.80	.0016	.0024	.49	.0330	.0000	.0462	2.6	.0020
13193	Oct. 24	None.	None.	0.01	7.40	.0000	.0022	.64	.0600	.0000	.0276	3.2	.0040

Odor, none. —— The samples were collected from the filter-gallery.

Microscopical Examination.

No organisms.

WELLESLEY.

Chemical Examination of Water from the Well of the Wellesley Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12426	June 25	None.	V. slight.	0.03	5.70	.0000	.0028	.60	.0430	.0000	.0531	2.3	.0010
13192	Oct. 24	None.	None.	0.03	6.50	.0000	.0036	.78	.0600	.0000	.0893	2.9	.0020

Odor, none. —— The samples were collected from the well at Williams Spring.

Microscopical Examination.

No organisms.

Water Supply of Westborough.

Chemical Examination of Water from the Upper Sandra Reservoir, Westborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11632	Jan. 15	Decided.	Cons., green.	0.50	3.20	1.50	.0036	.0328	.0208	.0120	.24	.0050	.0000	.5460	0.5
11891	Mar. 14	Distinct.	Slight.	0.30	2.25	0.90	.0310	.0190	.0146	.0044	.18	.0070	.0000	.3400	0.0
12230	May 16	Slight.	Heavy, fibrous.	0.43	2.15	1.15	.0010	.0288	.0160	.0128	.20	.0000	.0001	.4173	0.2
12568	July 17	Decided, green.	Slight, green.	0.45	3.75	1.70	.0000	.0396	.0186	.0210	.22	.0000	0000	.4774	0.3
12957	Sept. 11	Decided, green.	Cons., green.	0.40	4.55	2.00	.0010	.0772	.0326	.0446	.21	.0020	.0000	.4081	1.1
13311	Nov. 14	Distinct, green.	Cons., green.	0.28	4.00	2.20	.0000	.0330	.0176	.0154	.23	.0000	.0000	.6396	0.3
Av.	....	....	....	0.39	3.32	1.57	.0061	.0384	.0200	.0184	.21	.0023	.0000	.4714	0.4

Odor of No. 11632, decidedly oily; of No. 11891, distinctly vegetable and faintly oily; of No. 12230, distinctly vegetable, becoming oily on heating; of No. 12957, disagreeable; of the remaining samples, vegetable. —— The samples were collected from the upper reservoir.

WESTBOROUGH.

Microscopical Examination of Water from the Upper Sandra Reservoir, Westborough.

[Number of organisms per cubic centimeter.]

	1894.					
	Jan.	March.	May.	July.	Sept.	Nov.
Day of examination,	16	15	17	18	15	15
Number of sample,	11632	11891	12230	12568	12957	13311
PLANTS.						
Diatomaceæ,	**0**	**2**	**623**	**2**	**0**	**4**
Asterionella,	0	0	4	0	0	0
Melosira,	0	0	4	0	0	0
Synedra,	0	2	600	2	0	4
Tabellaria,	0	0	15	0	0	0
Cyanophyceæ,	**0**	**0**	**10**	**344**	**10,000**	**3,004**
Anabæna,	0	0	10	280	9,800	3,000
Chroöcoccus,	0	0	0	20	0	0
Clathrocystis,	0	0	0	44	200	4
Algæ,	**0**	**0**	**17**	**2,234**	**9,150**	**4,002**
Arthrodesmus,	0	0	3	0	0	0
Chlorococcus,	0	0	0	312	0	0
Polyedrium,	0	0	0	1,920	9,000	4,000
Protococcus,	0	0	6	0	0	0
Scenedesmus,	0	0	8	2	150	2
ANIMALS.						
Rhizopoda, Actinophrys,	**0**	**0**	**1**	**0**	**150**	**0**
Infusoria,	**188**	**62**	**20**	**8**	**200**	**3**
Ceratium,	0	0	5	0	0	0
Chlamydomonas,	5	0	1	0	0	0
Cryptomonas,	5	21	1	0	0	0
Dinobryon,	100	20	0	0	0	0
Dinobryon cases,	0	3	4	0	0	0
Glenodinium,	3	2	0	0	0	0
Mallomonas,	0	0	3	0	0	0
Monas,	0	0	1	4	200	0
Peridinium,	0	11	1	2	0	3
Trachelomonas,	5	0	0	2	0	0
Uroglena,	70	5	4	0	0	0
Vermes,	**3**	**0**	**0**	**0**	**0**	**0**
Anurea,	1	0	0	0	0	0
Polyarthra,	1	0	0	0	0	0
Rotifer,	1	0	0	0	0	0
Miscellaneous, Zoöglœa,	**76**	**0**	**92**	**0**	**350**	**0**
TOTAL,	267	64	763	2,588	19,850	7,013

WESTBOROUGH.

Chemical Examination of Water from the Lower Sandra Reservoir, Westborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dis-solved.	Sus-pended.					
	1894.														
11633	Jan. 15	Distinct.	Cons.	0.05	3.30	0.85	.0002	.0128	.0080	.0048	.20	.0000	.0000	.0998	1.4
11892	Mar. 14	Distinct.	Cons.	0.08	2.25	0.80	.0020	.0142	.0100	.0042	.18	.0050	.0001	.3640	0.3
12231	May 16	Slight.	Slight, white.	0.05	2.35	0.85	.0004	.0164	.0102	.0062	.21	.0000	.0000	.2379	0.6
12569	July 17	V. slight.	V. slight.	0.05	3.75	1.80	.0002	.0108	.0092	.0016	.26	.0030	.0000	.1625	0.8
12958	Sept. 11	Slight.	Slight.	0.10	4.65	2.15	.0004	.0128	.0116	.0012	.22	.0000	.0000	.1540	1.3
13312	Nov. 14	V. slight.	Slight.	0.08	2.60	0.50	.0024	.0086	.0060	.0026	.24	.0030	.0000	.1209	0.9
Av.	....	....	....	0.07	3.15	1.16	.0009	.0126	.0092	.0034	.22	.0018	.0000	.1898	0.9

Odor, generally vegetable; in January and March, oily. An oily odor was developed in the May sample on heating. —— The samples were collected from the lower reservoir.

Microscopical Examination of Water from the Lower Sandra Reservoir, Westborough.

[Number of organisms per cubic centimeter.]

	1894.					
	Jan.	Mar.	May.	July.	Sept.	Nov.
Day of examination,	16	15	17	18	15	16
Number of sample,	11633	11892	12231	12569	12958	13312
PLANTS.						
Diatomaceæ,	0	1	22	0	3	2
Asterionella,	0	0	7	0	0	0
Diatoma,	0	0	12	0	0	0
Melosira,	0	0	0	0	3	0
Synedra,	0	0	3	0	0	0
Tabellaria,	0	1	0	0	0	2
Cyanophyceæ, Chroöcoccus,	0	0	0	5	0	0
Algæ,	2	2	0	4	0	0
Protococcus,	0	0	0	4	0	0
Raphidium,	2	2	0	0	0	0
Fungi, Crenothrix,	0	0	0	4	4	0

WESTBOROUGH.

Microscopical Examination of Water from the Lower Sandra Reservoir, Westborough — Concluded.

[Number of organisms per cubic centimeter.]

	1894.					
	Jan.	Mar.	May.	July.	Sept.	Nov.
ANIMALS.						
Infusoria,	167	641	15	6	21	16
Ceratium,	0	0	1	0	0	0
Cryptomonas,	1	72	0	0	0	0
Dinobryon,	40	460	1	0	0	0
Dinobryon cases,	60	68	10	0	9	0
Glenodinium,	46	0	0	0	0	0
Monas,	pr.	2	0	0	0	0
Peridinium,	0	28	2	6	12	16
Synura,	0	1	0	0	0	0
Trachelomonas,	0	3	0	0	0	0
Uroglena,	20	7	0	0	0	0
Vorticella,	0	0	1	0	0	0
Vermes, Anurea,	0	1	0	0	0	0
Miscellaneous, Zoöglœa,	5	0	0	72	84	0
TOTAL,	174	645	37	91	112	18

WATER SUPPLY OF WESTBOROUGH INSANE HOSPITAL, WESTBOROUGH.

The water of the tubular wells from which the main supply of the hospital is derived has been characterized since the examinations of the State Board of Health were begun by a high free ammonia, which has increased with considerable regularity from year to year. In the year 1894 the increase has been much more marked than in previous years, and the amount of iron is much greater than in the previous year. The iron in the water oxidizes on exposure to the air and precipitates, giving the water first a milky turbidity and then causing a rusty sediment to deposit.

The advice of the State Board of Health to the superintendent of the Westborough Insane Hospital, in reply to an inquiry as to whether the water of Chauncy Pond would be suitable for drinking and domestic purposes if filtered, may be found on page 44 of this volume.

WESTBOROUGH.

Chemical Examination of Water from the Tubular Wells at the Westborough Insane Hospital.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
11792	Feb. 20	Distinct, milky.	None.	0.65	11.60	.1002	.0074	.37	.0030	.0000	.1440	6.1	.1550
12229	May 16	Distinct, milky.	None.	0.45	11.10	.0896	.0054	.40	.0000	.0000	.1131	5.6	.1500
12790	Aug. 20	Distinct, milky.	Slight, rusty.	0.30	11.50	.1056	.0132	.40	.0000	.0000	.1617	5.6	.1600
13303	Nov. 13	Distinct, milky.	Slight, fibrous.	0.15	12.80	.1800	.0070	.31	.0000	.0000	.1677	7.0	.2100
Av.	....	....	....	0.39	11.75	.1188	.0082	.37	.0007	.0000	.1466	6.1	.1687

Averages by Years.

-	1887*	-	-	0.03	11.29	.0407	.0033	.42	.0030	-	-	-	-
-	1888	-	-	0.06	11.27	.0502	.0051	.42	.0045	.0000	-	-	-
-	1889†	-	-	0.16	11.41	.0530	.0049	.43	.0030	.0000	-	-	-
-	1891‡	-	-	0.50	11.80	.0784	.0109	.43	.0040	.0000	-	6.0	-
-	1893§	-	-	0.33	11.09	.0758	.0056	.40	.0078	.0001	.1200	5.8	.0964
-	1894	-	-	0.39	11.75	.1188	.0082	.37	.0007	.0000	.1466	6.1	.1687

* June to December. † January to May. ‡ July, two samples. § January, March, May and July.

NOTE to analyses of 1894: Odor of the first sample, none, becoming distinctly vegetable and somewhat unpleasant on heating; of the second sample, very disagreeable, disappearing on heating; of the third sample, earthy, disappearing on heating; of the last sample, distinctly musty. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination of Water from the Tubular Wells at the Westborough Insane Hospital.

[Number of organisms per cubic centimeter.]

	1894. February.	1894. May.	1894. August.	1894. November.
Day of examination,	22	17	22	15
Number of sample,	11792	12229	12790	13303
PLANTS.				
Fungi, Crenothrix,	0	40	0	112
Miscellaneous, Zoöglœa,	0	0	272	0
TOTAL,	0	40	272	112

WATER SUPPLY OF WESTFIELD.

Chemical Examination of Water from the Westfield Water Works.

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
12218	May 13	Slight.	Slight.	0.40	2.65	1.05	.0012	.0110	.0090	.0020	.12	.0050	.0000	.4017	0.2
12219	May 13	Distinct.	Cons.	0.48	2.45	0.90	.0004	.0114	.0096	.0018	.10	.0050	.0000	.4072	0.3

Odor, faintly vegetable, becoming stronger on heating. —— The first sample was collected from the distributing reservoir; the last, from a faucet in the town.

Microscopical Examination.

No. 12218. Diatomaceæ, *Asterionella*, 3; *Epithemia*, 2; *Pinnularia*, 1; *Synedra*, 4; *Tabellaria*, 4. Algæ, *Closterium*, 1. Fungi, *Crenothrix*, 8. Miscellaneous, *Zoöglœa*, 47. Total, 70.

No. 12219. Diatomaceæ, *Asterionella*, 48; *Epithemia*, 28; *Gomphonema*, 1; *Pinnularia*, 1; *Synedra*, 44; *Tabellaria*, 6. Fungi, *Crenothrix*, 36. Total, 164.

WATER SUPPLY OF HORSE NECK BEACH, WESTPORT.

The advice of the State Board of Health to Mr. Thomas B. Tripp of New Bedford, relative to the introduction of a water supply at Horse Neck Beach, a summer resort in Westport, may be found on pages 44 and 45 of this volume. Analyses of samples of water collected in connection with the investigations of the Board are given below.

Chemical Examination of Water from a Tubular Well and a Spring, Westport.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1894.												
12077	April 21	Decided.	Cons., sandy.	0.02	14.70	.0012	.0086	2.61	.3100	.0001	.0197	4.2	.0100
12078	April 21	V. slight.	Cons., floc.	0.00	6.90	.0000	.0066	1.74	.0670	.0000	.0632	1.4	.0000

Odor, none. —— The first sample was collected from a tubular well 200 feet west of the farm-house on the Almy Farm; and the last sample from a spring near the base of a hill from 600 to 800 feet from the well from which the first sample was collected.

Microscopical Examination.

No. 12077. Cyanophyceæ, *Oscillaria*, 6.

No. 12078. Diatomaceæ, *Ceratoneis*, 4; *Epithemia*, 1; *Himantidium*, 425; *Meridion*, 3; *Navicula*, 3; *Odontidium*, 2; *Synedra*, 12; *Tabellaria*, 5. Cyanophyceæ, *Oscillaria*, 3. Vermes, *Anurea*, 1. Total, 459.

WEYMOUTH.

WATER SUPPLY OF WEYMOUTH.

Chemical Examination of Water from Great Pond, in Weymouth.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11924	Mar. 20	V. slight.	Slight.	1.00	3.95	1.90	.0006	.0192	.0180	.0012	.57	.0020	.0001	.8808	0.3
12438	June 26	Slight.	Cons.	0.80	3.90	1.25	.0000	.0160	.0140	.0020	.60	.0000	.0000	.6376	1.1
13054	Oct. 1	V. slight.	Slight.	0.58	3.70	1.25	.0000	.0148	.0130	.0018	.66	.0020	.0000	.4700	0.6
13555	Dec. 26	V. slight.	V. slight.	0.70	4.40	2.00	.0006	.0176	.0174	.0002	.60	.0020	.0000	.6930	0.9
Av.	....	....	....	0.77	3.99	1.60	.0003	.0169	.0156	.0013	.61	.0015	.0000	.6703	0.7

Averages by Years.

-	1887*	-	-	0.93	4.08	1.75	.0007	.0219	-	-	.47	.0030	-	-	-
-	1888†	-	-	0.88	4.15	1.94	.0020	.0225	-	-	.48	.0074	.0000	-	-
-	1889‡	-	-	1.40	-	-	.0000	.0230	.0220	.0010	-	.0040	.0000	-	-
-	1892	-	-	0.94	3.82	1.86	.0000	.0173	.0156	.0017	.51	.0077	.0000	-	0.4
-	1893	-	-	0.76	3.86	1.66	.0003	.0163	.0139	.0025	.57	.0008	.0000	.6847	0.5
-	1894	-	-	0.77	3.99	1.60	.0003	.0169	.0156	.0013	.61	.0015	.0000	.6703	0.7

* June to December. † January to May. ‡ July.

NOTE to analyses of 1894: Odor of the first three samples, vegetable; of the last, none.—— The first and last samples were collected from the pond, the others from faucets in the town.

Microscopical Examination of Water from Great Pond, in Weymouth.

[Number of organisms per cubic centimeter.]

	1894.			
	March.	July.	October.	December.
Day of examination, ...	21	2	2	28
Number of sample, ...	11924	12438	13054	13555
PLANTS.				
Diatomaceæ, Asterionella, ...	0	32	0	6
Algæ, Chlorococcus, ...	0	4	0	0
Fungi, Crenothrix, ...	0	27	24	0

WEYMOUTH.

Microscopical Examination of Water from Great Pond, in Weymouth — Concluded.

[Number of organisms per cubic centimeter.]

	1894.			
	March.	July.	October.	December.
ANIMALS.				
Infusoria,	68	1	0	0
Dinobryon,	12	0	0	0
Dinobryon cases,	54	0	0	0
Peridinium,	0	1	0	0
Tintinnidium,	2	0	0	0
Miscellaneous, Zoöglœa,	30	43	0	0
TOTAL,	98	107	24	6

WATER SUPPLY OF WINCHENDON.

The advice of the State Board of Health to the water committee of the town of Winchendon, relative to introducing a water supply into the town, may be found on pages 45–53 of this volume. Analyses of samples of water collected during the investigations of the Board are given below. Analyses of samples of water from Upper Naukeag Pond may be found on page 77 of this volume.

Chemical Examination of Water from Beaman Brook, in Winchendon.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
12094	1894. Apr. 24	V. slight.	Slight.	1.50	3.50	2.25	.0008	.0186	.0166	.0020	.10	.0030	.0000	1.1747	0.6

Odor, very faintly vegetable. —— The sample was collected from the brook, near the line between Massachusetts and New Hampshire.

Microscopical Examination.

Diatomaceæ, *Amphora*, 3; *Ceratoneis*, 3; *Meridion*, 3; *Navicula*, 1; *Synedra*, 3; *Tabellaria*, 42. Algæ, *Conferva*, 2; *Cosmarium*, 1. Total, 58.

WINCHENDON.

Chemical Examination of Water from Test Wells in the Prentice Meadow, Winchendon.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
12188	May 10	None.	V. slight.	0.01	1.80	.0000	.0004	.07	.0000	.0000	.0451	0.2	.0000
13092	Oct. 6	None.	Slight.	0.00	2.90	.0000	.0014	.09	.0000	.0000	.0213	0.3	.0020

Odor, none. —— The first sample was collected from test well No. 3 in the Prentice Meadow, bordering Miller's River, a little more than a mile above Winchendon and near the first crossing of the Cheshire Division of the Fitchburg Railroad over the river. The last sample was collected from a well 20 feet in depth, dug at the place where test well No. 3 was located.

Microscopical Examination.

No organisms.

Chemical Examination of Water from Miller's River, above Winchendon.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
12187	May 10	Slight.	Slight.	1.80	3.50	2.10	.0008	.0236	.0216	.0020	.14	.0000	.0000	1.3448	0.3

Odor, distinctly vegetable. —— The sample was collected from Miller's River, about two miles above Winchendon.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 8; *Cocconeis*, 2; *Pinnularia*, 3; *Synedra*, 2. Algæ, *Closterium*, 1. Fungi, *Crenothrix*, 1. Infusoria, *Monas*, 1. Miscellaneous, *Zoöglœa*, 76. Total, 94.

Water Supply of Winchester.

Chemical Examination of Water from the North Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11739	Feb. 12	Slight.	Slight.	0.02	4.90	1.50	.0034	.0158	.0120	.0038	.61	.0070	.0000	.2496	1.9
12045	Apr. 16	V. slight.	Slight.	0.05	5.70	2.05	.0000	.0170	.0128	.0042	.82	.0250	.0002	.2280	2.3
12367	June 13	Slight.	V. slight.	0.08	6.05	2.45	.0018	.0216	.0164	.0052	.79	.0180	.0003	.2449	2.5
12469	July 5	Distinct, green.	Slight.	0.08	5.80	1.60	.0024	.0202	.0166	.0036	.80	.0030	.0001	.2102	2.5
12659	Aug. 6	Distinct, green.	Slight, green.	0.05	6.15	2.15	.0000	.0210	.0178	.0032	.88	.0000	.0000	.2542	2.6
12856	Sept. 4	Slight, green.	Slight, brown.	0.18	6.15	1.75	.0012	.0190	.0168	.0022	.82	.0000	.0001	.2387	2.7
13059	Oct. 2	Distinct, green.	Cons., brown.	0.10	6.10	2.10	.0010	.0242	.0174	.0068	.88	.0000	.0000	.3041	2.6
13256	Nov. 5	Distinct.	Slight.	0.10	5.55	1.45	.0026	.0194	.0158	.0036	.87	.0030	.0001	.2502	2.5
13426	Dec. 4	Slight.	Cons.	0.18	6.25	1.65	.0030	.0200	.0180	.0020	.91	.0120	.0002	.2618	2.6
Av.	....	....	....	0.09	5.85	1.86	.0017	.0198	.0160	.0038	.82	.0076	.0001	.2491	2.5

Averages by Years.

-	1887*	-	-	.11	5.08	1.18	.0015	.0196	-	-	.53	.0037	-	-	-
-	1888	-	-	.15	4.93	1.24	.0045	.0273	-	-	.47	.0131	.0003	-	-
-	1889	-	-	.13	4.52	1.18	.0022	.0223	.0176	.0047	.47	.0105	.0003	-	-
-	1890	-	-	.09	5.30	1.31	.0017	.0201	.0160	.0041	.52	.0153	.0002	-	2.7
-	1891	-	-	.10	4.94	1.39	.0034	.0222	.0169	.0053	.51	.0152	.0001	-	2.1
-	1892	-	-	.06	5.23	1.59	.0058	.0217	.0177	.0040	.60	.0192	.0002	-	2.5
-	1893	-	-	.07	5.13	1.62	.0055	.0252	.0172	.0080	.59	.0127	.0002	.2718	2.3
-	1894	-	-	.09	5.85	1.86	.0017	.0198	.0160	.0038	.82	.0076	.0001	.2491	2.5

* June to December.

Note to analyses of 1894: Odor, generally vegetable, occasionally mouldy or unpleasant; in December, none. —— The samples were collected from the reservoir, about one foot beneath the surface.

WINCHESTER.

Microscopical Examination of Water from the North Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1894.								
	Feb.	Apr.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	13	17	14	6	7	5	3	5	5
Number of sample,	11739	12045	12367	12469	12659	12856	13059	13256	13426
PLANTS.									
Diatomaceæ,	**0**	**1,586**	**60**	**0**	**10**	**39**	**1,064**	**31**	**37**
Asterionella,	0	1,360	0	0	0	0	944	21	31
Cyclotella,	0	56	0	0	0	0	40	8	2
Melosira,	0	120	0	0	10	39	80	0	0
Stephanodiscus,	0	0	60	0	0	0	0	0	0
Synedra,	0	40	0	0	0	0	0	1	4
Tabellaria,	0	10	0	0	0	0	0	1	0
Cyanophyceæ,	**3**	**0**	**15**	**2**	**9**	**9**	**58**	**111**	**12**
Anabæna,	0	0	3	1	1	0	9	100	10
Clathrocystis,	0	0	0	0	1	0	5	1	0
Cœlosphærium,	3	0	8	1	7	3	44	9	2
Microcystis,	0	0	4	0	0	6	0	1	0
Algæ,	**0**	**10**	**300**	**6**	**0**	**4**	**12**	**138**	**6**
Chlorococcus,	0	6	0	0	0	0	0	0	0
Protococcus,	0	0	300	6	0	0	5	137	6
Raphidium,	0	4	0	6	0	0	0	0	0
Staurastrum,	0	0	0	0	0	4	7	1	0
Fungi, Crenothrix,	**0**	**6**	**0**	**0**	**0**	**2**	**1**	**0**	**0**
ANIMALS.									
Infusoria,	**6**	**186**	**34**	**1**	**5**	**175**	**30**	**25**	**0**
Ceratium,	0	0	0	0	1	0	3	0	0
Chlamydomonas,	5	0	0	0	0	0	0	0	0
Dinobryon,	0	6	5	0	0	1	0	2	0
Dinobryon cases,	0	180	22	1	0	132	0	10	0
Euglena,	0	0	0	0	0	0	2	0	0
Mallomonas,	0	0	7	0	1	3	2	0	0
Peridinium,	0	0	0	0	1	3	3	2	0
Trachelomonas,	1	0	0	0	2	36	20	4	0
Vorticella,	0	0	0	0	0	0	0	7	0
Vermes,	**0**	**0**	**0**	**1**	**0**	**1**	**4**	**2**	**0**
Anurea,	0	0	0	1	0	0	1	2	0
Rotatorian ova,	0	0	0	0	0	0	2	0	0
Rotifer,	0	0	0	0	0	1	1	0	0
Crustacea, Cyclops,	**0**	**0**	**0**	**0**	**0**	**.01**	**.01**	**0**	**.02**
Miscellaneous, Zoöglœa,	**7**	**0**	**10**	**56**	**268**	**240**	**132**	**0**	**0**
TOTAL,	16	1,788	419	66	292	470	1,301	307	55

WINCHESTER.

Chemical Examination of Water from the South Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
11740	Feb. 12	Slight.	Slight.	0.10	3.95	1.50	.0026	.0274	.0188	.0086	.39	.0070	.0000	.3680	1.9
12046	Apr. 16	Slight.	Slight.	0.30	4.20	1.25	.0038	.0232	.0218	.0014	.40	.0030	.0001	.4744	1.8
12369	June 13	Distinct, green.	Cons., green.	0.25	4.60	0.70	.0004	.0304	.0254	.0050	.40	.0030	.0000	.4712	1.9
12405	June 20	Distinct.	Cons., white.	0.25	4.65	1.60	.0028	.0374	.0334	.0040	.38	.0000	.0000	.4928	1.8
12468	July 5	Distinct.	Slight, green.	0.12	4.95	1.95	.0012	.0272	.0254	.0018	.41	.0000	.0000	.4166	1.9
12573	July 18	Slight.	Slight.	0.15	4.75	2.25	.0006	.0260	.0242	.0018	.43	.0000	.0000	.4435	1.7
12660	Aug. 6	Distinct, green.	Slight, green.	0.15	4.60	2.10	.0002	.0274	.0244	.0030	.42	.0000	.0001	.4928	1.7
12855	Sept. 4	Slight, green.	Slight, brown.	0.15	4.85	2.10	.0000	.0276	.0234	.0042	.37	.0000	.0002	.4235	1.9
13061	Oct. 2	Slight, green.	Slight, green.	0.15	4.55	2.25	.0000	.0228	.0212	.0016	.42	.0000	.0000	.4700	1.9
13257	Nov. 5	Distinct.	Cons., green.	0.25	4.45	1.80	.0218	.0266	.0224	.0042	.46	.0030	.0001	.4196	1.9
13428	Dec. 4	Slight.	V. slight.	0.18	4.95	1.60	.0136	.0246	.0226	.0020	.42	.0070	.0004	.4466	2.3
Av.*	....	....	....	0.18	4.56	1.76	.0049	.0267	.0232	.0035	.41	.0024	.0001	.4452	1.9

Averages by Years.

-	1891†	-	-	.60	5.73	2.09	.0110	.0486	.0361	.0125	.40	.0094	.0006	-	2.3
-	1892	-	-	.51	5.17	2.04	.0055	.0392	.0318	.0074	.38	.0118	.0002	-	2.2
-	1893	-	-	.34	4.78	1.86	.0064	.0291	.0216	.0075	.36	.0093	.0002	.4891	2.1
-	1894	-	-	.18	4.56	1.76	.0049	.0267	.0232	.0035	.41	.0024	.0001	.4452	1.9

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

† August to December.

NOTE to analyses of 1894: Odor, vegetable; in June, oily; on heating the odor is stronger. —— The samples were collected from the reservoir near the gate-house, one foot beneath the surface.

WINCHESTER.

Microscopical Examination of Water from the South Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1894.										
	Feb.	Apr	June.	June.	July.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	13	17	14	22	6	18	7	5	3	5	5
Number of sample,	11740	12046	12369	12405	12468	12573	12660	12855	13061	13257	13428
PLANTS.											
Diatomaceæ,	**pr.**	**243**	**228**	**29**	**19**	**8**	**32**	**109**	**29**	**14**	**24**
Asterionella,	0	16	0	0	0	0	0	0	0	0	8
Synedra,	0	3	0	0	0	0	0	0	0	4	0
Tabellaria,	pr.	224	228	29	19	8	32	109	29	10	16
Cyanophyceæ,	**9**	**5**	**7**	**18**	**2**	**18**	**33**	**3**	**7**	**80**	**0**
Anabæna,	pr.	0	2	18	2	0	15	0	3	72	0
Clathrocystis,	8	0	3	0	0	18	18	2	0	4	0
Cœlosphærium,	1	0	1	0	0	0	0	1	1	4	0
Microcystis,	0	5	1	0	0	0	0	0	3	0	0
Algæ,	**0**	**3**	**445**	**20**	**0**	**2**	**15**	**74**	**2**	**10**	**56**
Arthrodesmus,	0	0	1	6	0	1	0	1	0	0	0
Closterium,	0	3	19	8	0	0	1	68	2	2	56
Protococcus,	0	0	416	0	0	0	0	0	0	0	0
Raphidium,	0	0	4	2	0	0	12	4	0	8	0
Staurastrum,	0	0	5	4	0	1	2	1	0	0	0
Fungi, Crenothrix,	**0**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
ANIMALS.											
Infusoria,	**1**	**92**	**35**	**20**	**5**	**7**	**825**	**12**	**8**	**80**	**5**
Dinobryon,	0	0	0	0	0	2	20	0	0	0	0
Dinobryon cases,	0	88	0	0	0	5	800	4	0	0	0
Mallomonas,	0	0	0	0	0	0	3	1	0	0	0
Peridinium,	0	1	0	0	0	0	0	1	0	0	0
Trachelomonas,	1	3	0	0	5	0	2	6	8	80	5
Uroglena,	0	0	25	20	pr.	0	0	0	0	0	0
Volvox,	0	0	.10	0	0	0	0	0	0	0	0
Vermes,	**0**	**0**	**3**	**0**	**1**	**pr.**	**0**	**0**	**0**	**0**	**0**
Anurea,	0	0	1	0	0	pr.	0	0	0	0	0
Rotatorian ova,	0	0	2	0	1	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	**0**	**84**	**0**	**0**	**54**	**0**	**108**	**0**	**208**	**768**	**64**
TOTAL,	10	434	718	87	81	35	1,013	198	254	952	149

WINCHESTER.

Chemical Examination of Water from the Middle Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
12277	May 23	Slight.	Cons., yellow.	1.20	4.85	2.60	.0090	.0542	.0508	.0034	.39	.0070	.0001	.8736	1.4
12368	June 13	Distinct.	Slight.	1.10	4.95	2.65	.0160	.0690	.0514	.0176	.40	.0050	.0001	.9117	1.3
12404	June 20	Distinct.	Slight, white.	1.00	5.05	2.40	.0184	.0564	.0532	.0032	.40	.0030	.0001	.8532	1.3
12525	July 12	Decided, green.	Slight, green.	1.00	5.50	3.10	.0000	.0690	.0498	.0192	.48	.0000	.0000	.8224	1.9
12572	July 18	Thick, green.	Slight, green.	0.90	5.55	3.20	.0006	.0802	.0374	.0428	.49	.0030	.0000	.7900	1.4
12608	July 25	Decided, green.	Cons., yellow.	0.70	5.00	2.85	.0000	.0596	.0384	.0212	.46	.0000	.0001	.7338	1.1
12661	Aug. 6	Decided, green.	Cons., green.	0.50	5.25	2.75	.0020	.0768	.0438	.0330	.40	.0000	.0001	.7777	1.6
12854	Sept. 4	Decided, green.	Slight, brown.	0.60	6.00	3.20	.0018	.0910	.0510	.0400	.45	.0000	.0002	.7777	1.7
13060	Oct. 2	Decided, green.	Cons., green.	0.55	5.90	3.25	.0000	.0842	.0468	.0374	.48	.0000	.0001	1.0191	1.9
13313	Nov. 15	Decided, green.	Slight, green.	0.75	5.60	3.40	.0020	.0656	.0466	.0190	.45	.0070	.0000	.8931	1.6
13427	Dec. 4	Distinct.	Cons., green.	0.80	5.85	3.35	.0036	.0746	.0548	.0198	.44	.0070	.0001	.9086	1.4
Av.*	....	....	....	0.79	5.48	3.02	.0045	.0723	.0485	.0238	.44	.0032	.0001	.8643	1.5

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, generally distinctly vegetable and often unpleasant or disagreeable; in December, none. The odor is generally stronger on heating. —— The samples were collected from the reservoir above the dam. There is no means of drawing water directly from this reservoir for the supply of the town. The overflow from it passes into the South Reservoir.

WINCHESTER.

Microscopical Examination of Water from the Middle Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1894.										
	May.	June.	June.	July.	July.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	24	14	22	12	18	25	7	5	3	16	5
Number of sample,	12277	12368	12404	12525	12572	12608	12661	12854	13060	13313	13427
PLANTS.											
Diatomaceæ,	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**11**	**28**	**2**	**65**
Asterionella,	0	0	0	0	0	0	0	0	0	0	8
Fragilaria,	0	0	0	0	0	0	0	10	0	0	0
Melosira,	0	0	0	0	0	0	0	0	24	0	9
Navicula,	0	1	0	0	0	0	1	1	4	0	0
Synedra,	0	0	0	0	0	0	0	0	0	2	48
Cyanophyceæ,	**3**	**15**	**0**	**302**	**384**	**800**	**1,360**	**272**	**692**	**101**	**92**
Anabæna,	0	0	0	0	260	150	1,220	144	64	0	0
Chroöcoccus,	0	0	0	0	84	0	0	0	0	0	0
Clathrocystis,	3	15	0	288	40	500	32	48	144	1	0
Cœlosphærium,	0	0	0	2	0	150	108	72	480	100	92
Microcystis,	0	0	0	12	0	0	0	8	4	0	0
Algæ,	**59**	**23**	**18**	**122**	**179**	**100**	**12**	**80**	**204**	**60**	**14**
Cœlastrum,	0	0	0	0	0	0	0	48	12	0	2
Eudorina,	9	3	0	0	1	0	0	1	20	2	0
Pediastrum,	13	15	5	20	2	0	0	0	4	0	1
Nephrocytium,	1	0	0	0	0	0	12	4	0	0	0
Protococcus,	0	0	10	0	0	0	0	0	0	0	10
Scenedesmus,	0	0	0	2	0	0	0	0	0	6	0
Selenastrum,	0	0	0	0	0	0	0	25	160	52	0
Sorastrum,	32	4	2	80	172	50	0	1	0	0	0
Staurastrum,	4	1	1	20	4	0	0	1	8	0	1
Zoöspores,	0	0	0	0	0	50	0	0	0	0	0
Fungi, Crenothrix,	**1**	**0**	pr.	**6**	**0**	**0**	**C**	**3**	**8**	**0**	**5**
ANIMALS.											
Infusoria,	**224**	**14**	**60**	**38**	**69**	**100**	**3**	**44**	**416**	**851**	**6**
Bursaria,	0	14	0	0	0	0	0	0	0	0	0
Cryptomonas,	0	0	0	0	0	0	0	0	0	550	0
Dinobryon cases,	220	0	0	0	0	0	0	0	0	0	0
Monas,	0	0	0	0	1	0	1	0	0	0	0
Peridinium,	0	0	0	4	0	0	2	0	0	1	0
Trachelomonas,	1	0	60	34	68	100	0	44	416	300	6
Volvox,	3	0	0	0	0	0	0	0	0	0	0
Vermes,	**0**	**0**	pr.	**0**	**0**	**0**	**2**	**1**	**8**	**2**	**0**
Anurea,	0	0	0	0	0	0	0	0	4	0	0
Monocerca,	0	0	pr.	0	0	0	2	0	0	0	0
Polyarthra,	0	0	0	0	0	0	0	1	4	2	0
Crustacea,	**.03**	**.15**	**.01**	**.01**	**.02**	**0**	**.03**	**.01**	**0**	**.05**	**.02**
Bosmina,	0	.15	0	0	0	0	0	0	0	0	0
Cyclops,	.01	0	.01	.01	0	0	.02	0	0	.05	.02
Daphnia,	.02	0	0	0	.02	0	.01	.01	0	0	0
Miscellaneous,	**.01**	**0**	**.02**	**12**	**0**	**0**	**680**	**120**	**60**	**0**	**0**
Acarina,	.01	0	.02	.03	0	0	.01	.06	0	0	0
Zoöglœa,	0	0	0	12	0	0	680	120	60	0	0
TOTAL,	287	53	78	480	632	1,000	2,058	531	1,416	1,016	182

WATER SUPPLY OF WINTHROP.

(See *Revere*.)

WATER SUPPLY OF WOBURN.

Chemical Examination of Water from the Filter-gallery of the Woburn Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
11651	Jan. 17	None.	None.	.00	11.35	.0026	.0008	2.01	.0280	.0000	.0466	5.1	.0000
11782	Feb. 19	None.	None.	.00	10.80	.0026	.0020	2.00	.0280	.0000	.0640	5.0	.0000
11923	Mar. 20	None.	Slight.	.00	10.85	.0034	.0034	1.75	.0320	.0000	.0687	5.0	.0005
12071	Apr. 17	None.	None.	.00	11.30	.0000	.0012	2.20	.0350	.0000	.0351	5.0	.0010
12245	May 16	None.	None.	.00	11.40	.0030	.0012	1.92	.0250	.0000	.0468	5.1	.0000
12424	June 22	None.	None.	.05	12.05	.0022	.0010	2.02	.0350	.0000	.0577	5.1	.0040
12571	July 18	None.	None.	.02	10.80	.0026	.0016	1.94	.0300	.0000	.0493	4.9	.0060
12777	Aug. 15	None.	None.	.00	10.90	.0030	.0012	1.88	.0250	.0000	.0577	4.9	-
13004	Sept. 18	None.	None.	.00	12.00	.0032	.0018	2.02	.0280	.0000	.0346	5.5	.0050
13130	Oct. 15	None.	None.	.01	10.15	.0030	.0026	1.81	.0080	.0000	.0474	4.6	.0050
13330	Nov. 19	None.	None.	.02	10.40	.0036	.0024	1.78	.0160	.0000	.0515	4.6	.0010
13500	Dec. 17	None.	None.	.01	10.30	.0022	.0024	1.92	.0250	.0000	.0423	4.7	.0010
Av.	....	....	....	.01	11.02	.0026	.0018	1.94	.0262	.0000	.0501	5.0	.0021

Averages by Years.

-	1887*	-	-	.00	12.06	-	.0028	2.40	.0314	-	-	-	-
-	1888	-	-	.00	12.00	.0012	.0032	2.50	.0346	.0000	-	-	-
-	1889	-	-	.00	10.84	.0010	.0022	2.07	.0372	.0000	-	-	-
-	1890	-	-	.01	11.06	.0012	.0023	1.91	.0481	.0000	-	5.0	-
-	1891	-	-	.00	10.85	.0008	.0015	1.79	.0668	.0000	-	4.9	-
-	1892	-	-	.00	11.27	.00 2	.0024	1.95	.0542	.0000	-	5.1	-
-	1893	-	-	.00	11.50	.0022	.0018	2.04	.0447	.0000	.0517	5.3	.0004
-	1894	-	-	.01	11.02	.0026	.0018	1.94	.0262	.0000	.0501	5.0	.0021

* June to December.

NOTE to analyses of 1894: Odor, none. —— The samples were collected from the filter-gallery.

Microscopical Examination.

A very few organisms were found in the samples collected in March, May, July and September. In the remaining samples no organisms were found.

WOBURN.

Chemical Examination of Water from Horn Pond, Woburn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11650	Jan. 17	Slight.	Slight.	.40	9.60	2.35	.0066	.0130	.0108	.0022	1.79	.0900	.0007	.4519	3.2
11781	Feb. 19	Slight.	Slight.	.30	9.35	2.10	.0154	.0180	.0160	.0020	1.84	.0780	.0007	.3880	3.4
11922	Mar. 20	Slight.	Cons.	.35	8.70	2.50	.0040	.0276	.0164	.0112	1.56	.0900	.0010	.3950	3.0
12070	Apr. 17	Slight.	Cons.	.40	8.40	2.60	.0016	.0222	.0168	.0054	1.56	.0670	.0006	.3705	2.6
12244	May 16	Distinct.	Cons., green.	.30	6.15	1.40	.0178	.0186	.0162	.0024	1.56	.0480	.0018	.4134	3.1
12423	June 22	Distinct.	Slight, green.	.45	9.30	1.55	.0058	.0308	.0216	.0082	1.79	.0330	.0017	.4558	3.1
12570	July 18	Distinct, green.	Slight, green.	.33	7.75	1.75	.0000	.0296	.0200	.0096	1.81	.0170	.0019	.4258	3.1
12776	Aug. 15	Distinct, green.	Cons., green.	.30	9.05	1.85	.0004	.0388	.0200	.0188	1.94	.0000	.0001	.3388	3.6
13003	Sept. 18	Decided.	Cons., green.	.40	10.15	2.15	.0006	.0428	.0182	.0246	2.04	.0000	.0000	.3657	3.5
13129	Oct. 15	Distinct, green.	Cons., green.	.20	9.45	2.15	.0008	.0418	.0214	.0204	2.05	.0000	.0000	.4713	3.5
13329	Nov. 19	Slight.	Cons.	.28	10.30	1.45	.0194	.0394	.0218	.0176	2.10	.0200	.0011	.3884	3.6
13499	Dec. 17	Distinct.	Slight.	.28	10.20	1.95	.0056	.0278	.0212	.0066	2.01	.0420	.0009	.3811	3.6
Av.	....	....	....	.33	9.03	1.98	.0065	.0292	.0184	.0108	1.84	.0404	.0009	.4038	3.3

Averages by Years.

–	1887*	–	–	.44	13.79	2.19	.0149	.0480	–	–	3.74	.0224	.0014	–	–
–	1888	–	–	.32	11.28	1.71	.0186	.0383	–	–	2.98	.0398	.0015	–	–
–	1889	–	–	.30	8.37	2.03	.0092	.0376	.0216	.0160	1.98	.0498	.0015	–	–
–	1890	–	–	.27	10.76	2.07	.0080	.0368	.0205	.0163	1.91	.0581	.0008	–	3.4
–	1891	–	–	.22	8.90	2.06	.0129	.0453	.0237	.0216	1.76	.0502	.0009	–	2.9
–	1892	–	–	.25	10.57	2.13	.0110	.0358	.0216	.0142	2.42	.0821	.0008	–	3.3
–	1893	–	–	.30	9.83	2.51	.0061	.0455	.0247	.0208	2.10	.0472	.0009	.4530	3.2
–	1894	–	–	.33	9.03	1.98	.0065	.0292	.0184	.0108	1.84	.0404	.0009	.4038	3.3

* June to December.

NOTE to analyses of 1894: Odor, distinctly vegetable and frequently grassy; on heating, the odor was frequently disagreeable.

WOBURN.

Microscopical Examination of Water from Horn Pond, Woburn.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	20	20	18	21	23	18	18	21	16	21	19
Number of sample,	11650	11781	11922	12070	12244	12423	12570	12776	13003	13129	13329	13499
PLANTS.												
Diatomaceæ,	**49**	**427**	**927**	**906**	**393**	**11**	**7,280**	**20**	**204**	**682**	**883**	**101**
Asterionella,	2	160	640	396	11	0	0	0	0	0	880	60
Cyclotella,	3	6	2	0	1	0	0	0	0	0	0	0
Fragilaria,	0	8	0	10	100	10	7,280	20	202	320	0	0
Melosira,	0	136	264	280	13	0	0	0	0	37	3	40
Nitzschia,	0	112	0	0	0	0	0	0	0	1	0	0
Synedra,	44	5	21	220	268	1	0	0	2	324	0	1
Cyanophyceæ,	**0**	**0**	**1**	**0**	**15**	**27**	**80**	**296**	**160**	**62**	**88**	**0**
Anabæna,	0	0	0	0	10	0	0	0	0	0	0	0
Chroöcoccus,	0	0	0	0	0	0	40	0	0	0	0	0
Clathrocystis,	0	0	0	0	2	1	40	204	0	14	0	0
Cœlosphærium,	0	0	1	0	3	26	0	92	160	48	88	0
Algæ,	**14**	**57**	**175**	**0**	**13**	**384**	**188**	**75**	**550**	**88**	**80**	**1**
Chlorococcus,	0	44	10	0	0	0	0	0	0	0	0	0
Cosmarium,	0	10	0	0	0	0	1	0	520	4	0	0
Glœocapsa,	0	0	0	0	0	0	0	72	0	0	0	0
Protococcus,	12	0	164	0	5	240	0	0	0	56	0	0
Scenedesmus,	0	3	1	0	8	28	184	2	30	28	80	1
Staurastrum,	2	0	0	0	0	116	3	1	0	0	0	0
Fungi, Crenothrix,	**4**	**5**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
ANIMALS.												
Rhizopoda, Difflugia,	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**
Infusoria,	**6**	**0**	**129**	**4**	**2**	**2**	**2**	**0**	**0**	**7**	**1**	**2**
Cryptomonas,	0	0	128	0	1	0	0	0	0	7	0	2
Monas,	0	0	1	0	1	0	0	0	0	0	0	0
Peridinium,	5	0	0	1	0	0	2	0	0	0	0	0
Trachelomonas,	1	0	0	3	0	0	0	0	0	0	1	0
Vorticella,	0	0	0	0	0	2	0	0	0	0	0	0
Vermes, Anurea,	**0**	**0**	**1**	**0**	**4**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Crustacea,	**0**	**0**	**0**	**.03**	**.02**	**.01**	**0**	**0**	**.04**	**.02**	**.01**	**0**
Daphnia,	0	0	0	.03	0	.01	0	0	.02	0	0	0
Crustacean remains,	0	0	0	0	.02	0	0	0	.02	.02	.01	0
Miscellaneous, Zoöglœa,	**6**	**2**	**72**	**0**	**240**	**0**	**0**	**144**	**0**	**200**	**0**	**0**
TOTAL,	79	492	1,306	910	667	425	7,550	535	916	1,039	1,053	105

WORCESTER.

Water Supply of Worcester.

Leicester Supply. — *Chemical Examination of Water from the Lynde Brook Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11634	Jan. 5	V. slight.	Slight.	0.40	3.65	1.10	.0054	.0136	.0114	.0022	.19	.0120	.0000	.3315	3.0
11746	Feb. 12	V. slight.	V. slight.	0.28	3.65	1.05	.0080	.0104	.0086	.0018	.20	.0150	.0000	.3680	1.3
11876	Mar. 12	Slight.	Slight.	0.28	2.45	0.90	.0030	.0104	.0080	.0024	.15	.0150	.0000	.3784	0.8
12053	Apr. 16	Slight.	Slight.	0.20	2.55	0.85	.0034	.0106	.0092	.0014	.19	.0170	.0000	.3152	0.8
12203	May 14	Slight.	Cons.	0.20	2.75	0.85	.0010	.0118	.0108	.0010	.16	.0100	.0000	.3198	0.8
12384	June 18	V. slight.	Slight.	0.33	2.75	0.95	.0008	.0128	.0118	.0010	.17	.0030	.0000	.4050	0.9
12534	July 16	Slight.	Slight.	0.30	3.00	1.25	.0006	.0148	.0130	.0018	.20	.0000	.0002	.3311	0.9
12740	Aug. 13	Slight.	Slight.	0.23	3.50	1.10	.0000	.0150	.0138	.0012	.15	.0020	.0000	.3157	0.6
12968	Sept. 17	V. slight.	V. slight.	0.28	3.10	0.85	.0000	.0138	.0116	.0022	.21	.0000	.0000	.2849	0.9
13131	Oct. 15	Slight.	Cons.	0.75	3.20	1.20	.0184	.0230	.0142	.0088	.17	.0020	.0000	.3278	1.1
13327	Nov. 19	Distinct.	Slight.	0.65	4.80	1.45	.0130	.0156	.0146	.0010	.25	.0180	.0000	.4485	2.1
13501	Dec. 17	Slight.	V. slight.	0.45	5.00	1.55	.0130	.0148	.0132	.0016	.16	.0300	.0000	.4004	1.8
Av.	....	....	....	0.36	3.37	1.09	.0055	.0139	.0117	.0022	.18	.0103	.0000	.3522	1.2

Averages by Years.

-	1887*	-	-	0.30	3.15	0.95	.0057	.0194	-	-	.15	.0043	-	-	-
-	1888	-	-	0.24	2.64	0.85	.0037	.0151	-	-	.14	.0065	.0001	-	-
-	1889	-	-	0.24	2.54	0.60	.0030	.0167	.0138	.0029	.15	.0053	.0001	-	-
-	1890	-	-	0.21	3.07	1.15	.0026	.0132	.0107	.0025	.14	.0078	.0001	-	0.9
-	1891	-	-	0.24	2.83	1.03	.0045	.0126	.0101	.0025	.12	.0074	.0001	-	0.7
-	1892	-	-	0.25	2.99	1.15	.0038	.0139	.0113	.0026	.15	.0105	.0000	-	0.8
-	1893	-	-	0.26	2.66	0.98	.0036	.0162	.0122	.0039	.15	.0066	.0001	.3465	0.6
-	1894	-	-	0.36	3.37	1.09	.0055	.0139	.0117	.0022	.18	.0103	.0000	.3522	1.2

* June to December.

Note to analyses of 1894: Odor, generally vegetable, sometimes none. —— The samples were collected from the reservoir near the gate-house about one foot beneath the surface. This reservoir failed to fill in the spring of 1894 and was drawn down rapidly during the latter part of the summer and autumn and was practically empty in December. This condition probably accounts for the high color of the water in the last three months of the year.

WORCESTER.

Microscopical Examination of Water from the Lynde Brook Storage Reservoir.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	16	14	13	18	15	21	17	15	18	16	21	19
Number of sample,	11634	11746	11876	12053	12203	12384	12534	12740	12968	13131	13327	13501
PLANTS.												
Diatomaceæ,	**2**	**0**	**pr.**	**4**	**11**	**4**	**57**	**56**	**32**	**33**	**44**	**11**
Asterionella,	2	0	pr.	2	0	0	50	0	0	1	43	3
Cyclotella,	0	0	0	0	4	4	7	56	32	2	1	0
Melosira,	0	0	0	0	0	0	0	0	0	30	0	0
Synedra,	0	0	pr.	1	1	0	0	0	0	0	0	7
Tabellaria,	0	0	0	1	6	0	0	0	0	0	0	1
Cyanophyceæ,	**0**	**0**	**0**	**0**	**1**	**330**	**30**	**1**	**93**	**2**	**0**	**0**
Anabæna,	0	0	0	0	1	2	9	1	25	0	0	0
Chröococcus,	0	0	0	0	0	328	0	0	68	2	0	0
Merismopedia,	0	0	0	0	0	0	21	0	0	0	0	0
Algæ,	**0**	**0**	**0**	**0**	**312**	**12**	**212**	**344**	**26**	**8**	**0**	**0**
Glœocapsa,	0	0	0	0	0	0	0	344	0	0	0	0
Protococcus,	0	0	0	0	300	12	196	0	26	8	0	0
Raphidium,	0	0	0	0	0	0	16	0	0	0	0	0
Staurogenia,	0	0	0	0	12	0	0	0	0	0	0	0
ANIMALS.												
Infusoria,	**2**	**26**	**41**	**42**	**8**	**106**	**1**	**4**	**1**	**11**	**23**	**2**
Cryptomonas,	0	0	0	0	0	2	0	0	0	0	0	0
Dinobryon,	0	0	20	0	0	0	0	0	0	10	0	0
Dinobryon cases,	r.	24	20	40	5	104	0	0	0	0	23	2
Glenodinium,	2	0	0	0	0	0	0	0	0	0	0	0
Mallomonas,	0	0	0	0	0	0	0	4	0	0	0	0
Peridinium,	pr.	2	1	0	0	0	1	0	1	1	0	0
Tintinnidium,	0	0	0	2	0	0	0	0	0	0	0	0
Vorticella,	0	0	0	0	3	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	**0**	**3**	**0**	**0**	**11**	**0**	**0**	**0**	**80**	**204**	**0**	**0**
TOTAL,	4	29	41	46	343	452	300	405	232	258	67	13

WORCESTER.

HOLDEN SUPPLY. — *Chemical Examination of Water from the Tatnuck Brook Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
11635	Jan. 5	Slight.	Slight.	0.30	2.40	0.80	.0018	.0150	.0124	.0026	.19	.0050	.0000	.3299	0.5
11747	Feb. 12	V. slight.	V. slight.	0.20	2.35	1.00	.0034	.0116	.0090	.0026	.16	.0050	.0000	.3464	0.3
11877	Mar. 12	V. slight.	V. slight.	0.25	2.30	0.95	.0028	.0104	.0082	.0022	.14	.0120	.0000	.3352	0.2
12052	Apr. 16	Slight.	Slight.	0.15	1.65	0.55	.0004	.0098	.0068	.0030	.16	.0050	.0000	.2720	0.2
12204	May 14	Distinct.	Cons.	0.20	2.35	0.80	.0004	.0140	.0120	.0020	.13	.0000	.0000	.3003	0.3
12385	June 18	Slight.	Slight.	0.30	2.05	0.50	.0026	.0152	.0112	.0040	.15	.0030	.0000	.3388	0.3
12535	July 16	Distinct.	Slight.	0.20	2.30	1.00	.0000	.0158	.0118	.0040	.21	.0000	.0000	.2926	0.5
12741	Aug. 13	Distinct, green.	Slight, green.	0.25	3.20	0.85	.0006	.0168	.0112	.0056	.11	.0020	.0000	.2348	0.2
12967	Sept. 17	Slight.	Cons.	0.20	2.40	0.90	.0000	.0160	.0118	.0042	.19	.0000	.0000	.2541	0.5
13132	Oct. 15	Distinct.	Cons.	0.08	1.70	1.00	.0000	.0236	.0136	.0100	.18	.0000	.0000	.2923	0.3
13328	Nov. 19	Slight.	Cons.	0.20	2.15	0.80	.0000	.0174	.0148	.0026	.20	.0000	.0000	.2980	0.6
13502	Dec. 17	Slight.	Slight.	0.12	2.40	1.00	.0002	.0162	.0142	.0020	.13	.0070	.0000	.2787	0.8
Av.	....	....	....	0.20	2.27	0.85	.0010	.0151	.0114	.0037	.16	.0032	.0000	.2978	0.4

Averages by Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
–	1887*	–	–	0.29	2.62	1.01	.0007	.0197	–	–	.14	.0016	–	–	–
–	1888	–	–	0.17	2.23	0.75	.0012	.0157	–	–	.12	.0043	.0001	–	–
–	1889	–	–	0.19	2.04	0.57	.0003	.0143	.0112	.0031	.12	.0031	.0001	–	–
–	1890	–	–	0.17	2.68	1.24	.0007	.0141	.0102	.0039	.13	.0078	.0001	–	0.9
–	1891	–	–	0.17	2.30	0.94	.0024	.0143	.0102	.0041	.11	.0077	.0001	–	0.4
–	1892	–	–	0.20	2.52	1.03	.0012	.0142	.0113	.0029	.12	.0067	.0000	–	0.5
–	1893	–	–	0.35	2.45	0.93	.0020	.0182	.0140	.0042	.14	.0049	.0000	.3594	0.5
–	1894	–	–	0.20	2.27	0.85	.0010	.0151	.0114	.0037	.16	.0032	.0000	.2978	0.4

* June to December.

NOTE to analyses of 1894: Odor, vegetable and sometimes unpleasant. —— The samples were collected from the reservoir near the gate-house, one foot beneath the surface. For heights of water at times when samples were collected, see page 362.

WORCESTER.

Microscopical Examination of Water from the Tatnuck Brook Storage Reservoir.

[Number of organisms per cubic centimeter.]

	1894.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	16	14	13	18	15	21	17	15	18	16	21	19
Number of sample, . .	11635	11747	11877	12052	12204	12385	12535	12741	12967	13132	13328	13502
PLANTS.												
Diatomaceæ, . .	**2**	**5**	**0**	**243**	**413**	**10**	**545**	**2,364**	**113**	**713**	**1,322**	**304**
Asterionella, . .	pr.	0	0	80	72	5	276	1,920	22	116	552	240
Fragilaria, . . .	0	0	0	0	0	0	0	16	5	10	0	0
Melosira, . . .	0	4	0	130	176	0	0	0	28	368	404	0
Navicula, . . .	1	0	0	0	0	0	1	0	0	3	1	0
Synedra, . . .	1	0	0	3	5	4	0	0	0	0	1	5
Tabellaria, . . .	0	1	0	30	160	1	268	428	58	216	364	59
Cyanophyceæ, . .	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**43**	**13**	**32**	**0**	**0**
Anabæna, . . .	0	0	0	0	0	0	0	11	1	0	0	0
Cœlosphærium, . .	0	0	0	0	0	0	0	32	12	32	0	0
Algæ, ...	**pr.**	**pr.**	**0**	**3**	**13**	**0**	**0**	**0**	**13**	**4**	**92**	**13**
Chlorococcus, . .	0	0	0	0	0	0	0	0	5	2	20	0
Hyalotheca, . . .	0	0	0	0	0	0	0	0	0	0	13	0
Protococcus, . .	0	0	0	0	0	0	0	0	0	0	48	6
Raphidium, . . .	0	0	0	0	0	0	0	0	8	0	0	0
Scenedesmus, . .	pr.	pr.	0	3	1	0	0	0	0	2	11	7
Tetraspora, . . .	0	0	0	0	12	0	0	0	0	0	0	0
ANIMALS.												
Rhizopoda,												
Actinophrys, . .	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Infusoria, . . .	**40**	**9**	**2**	**40**	**8**	**76**	**26**	**44**	**9**	**3**	**5**	**5**
Dinobryon, . . .	0	0	0	5	0	0	0	0	0	0	0	0
Dinobryon cases, .	34	2	0	35	0	0	0	0	0	0	0	5
Euglena, . . .	0	0	0	0	0	0	0	0	0	0	5	0
Mallomonas, . . .	0	0	0	0	1	0	0	0	1	0	0	0
Peridinium, . . .	6	7	2	0	7	76	26	44	8	3	0	0
Vermes, ...	**1**	**0**	**pr.**	**1**	**1**	**2**	**0**	**0**	**0**	**0**	**1**	**0**
Anurea, . . .	1	0	0	0	1	0	0	0	0	0	1	0
Polyarthra, . . .	pr.	0	pr.	1	0	2	0	0	0	0	0	0
Miscellaneous, Zoöglœa, .	**2**	**5**	**0**	**40**	**11**	**0**	**0**	**160**	**244**	**88**	**0**	**0**
TOTAL, ...	47	19	2	327	446	88	571	2,611	392	840	1,420	322

WORCESTER.

Record of Height of Water in Leicester and Holden Storage Reservoirs at times when Samples of Water were collected for Analysis.

NOTE. — Leicester Reservoir, height of rollway, 37.40 feet; Holden Reservoir, height of rollway, 30.10 feet.

Date.	Height of Water.		Date.	Height of Water.	
	Leicester.	Holden.		Leicester.	Holden.
1894.	Feet.	Feet.	1894.	Feet.	Feet.
Jan. 5,	23.85	22.50	July 16,	28.55	28.10
Feb. 12,	21.50	23.10	Aug. 13,	25.25	25.20
March 12,	28.15	30.10	Sept. 17,	19.15	21.10
April 16,	30.80	30.30	Oct. 15,	13.75	19.00
May 14,	31.47	29.70	Nov. 19,	10.80	17.80
June 18,	31.67	29.80	Dec. 17,	9.30	17.90

Chemical Examination of Water from Bottomly Pond in Paxton, and Kettle Brook in Leicester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13218	Oct. 25	Distinct	Heavy, earthy.	0.35	4.15	1.15	.0214	.0302	.0156	.0146	.21	.0050	.0000	.3579	1.9
13219	Oct. 25	Slight.	Cons.	0.40	4.05	0.85	.0054	.0164	.0134	.0030	.23	.0050	.0001	.3871	1.8
13220	Oct. 25	Slight.	Cons.	0.25	3.95	1.80	.0090	.0278	.0188	.0090	.19	.0030	.0002	.4424	1.1

Odor of the first sample, faintly vegetable and mouldy; of the others, distinctly vegetable. —— The first sample was collected from Bottomly Pond; the second from a mill-pond on Kettle Brook at Mannville; the third from a mill-pond on Kettle Brook below Mannville.

Microscopical Examination.

No. 13218. The total number of organisms per cubic centimeter found in this sample was 1,108, consisting chiefly of Diatomaceæ, *Melosira* (464), and *Synedra* (520).

Nos. 13219 and 13220 contained, respectively, 433 and 130 organisms per cubic centimeter.

WORCESTER.

Chemical Examination of Water from Lake Quinsigamond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
13222	1894. Oct. 26	V. slight.	Slight.	0.12	3.70	1.00	.0020	.0148	.0126	.0022	.27	.0000	.0000	.2488	1.6

Odor, decidedly vegetable.—— The sample was collected from the upper end of the lake, at the Lincoln Street crossing.

Microscopical Examination.

Diatomaceæ, *Cymbella*, 1; *Diatoma*, 4; *Fragilaria*, 23; *Gomphonema*, 1; *Synedra*, 2. Algæ, *Chlorococcus*, 6; *Conferva*, 1. Total, 38.

EXAMINATION OF RIVERS.

EXAMINATION OF RIVERS.

Regular monthly examinations have been made during the year 1894 of the waters of the Blackstone, Charles, Deerfield, Hoosac, Housatonic, Merrimack, Nashua, Neponset, Saugus, Shawsheen, Taunton and Ware Rivers, and occasional examinations of other rivers in the State. Of these, the examinations of the Charles, Deerfield, Shawsheen, Ware and a large portion of those of the Nashua were made in connection with the investigation for a metropolitan water supply. Examinations were made of three streams, the Assabet in Maynard and Acton, the Green River in Deerfield and Greenfield, and the Miller's River at Orange, in consequence of complaints as to their sanitary condition.

Nearly all of the results of these examinations will be found arranged alphabetically by rivers in the pages which follow, but some of them are given on preceding pages in connection with the examinations of water supplies, under the names of the towns where the samples were collected, as follows: —

	Page
Neponset at Hyde Park, ...	186
Merrimack at Lawrence, ...	190
Merrimack at Lowell, ...	202
Saugus at Saugus, ...	215–217
Taunton at Taunton, ...	325

Assabet River.

Chemical Examination of Water from the Assabet River and Tributaries above Northborough.

[Parts per 100,000.]

Number.	Source.	Date of Collection.	Appearance.			Odor.	
			Turbidity.	Sediment.	Color.	Cold.	Hot.
		1893.					
10840	Assabet River, above Westborough sewage disposal beds.	Aug. 16	V. slight.	V. slight.	0.45	Distinctly vegetable and mouldy.	Distinctly vegetable and mouldy.
10843	Hop Brook, just above Bummet Brook, Northborough.	Aug. 16	V. slight.	V. slight.	0.20	None.	Faintly vegetable and mouldy.
10839	Mill-pond fed by Hop and Bummet brooks, Northborough.	Aug. 16	Decided, green.	Cons., yellow.	0.48	Distinctly vegetable.	Distinctly vegetable.
10838	Cold Harbor Brook, 1 mile above Northborough.	Aug. 16	None.	V. slight.	0.48	Faintly vegetable.	Faintly vegetable.
10842	Howard Brook, 1 mile above Northborough.	Aug. 16	Slight.	Cons., dark.	0.30	None.	Faintly vegetable.
10814	Tributary of North Brook, ½ mile north-west of West Berlin.	Aug. 15	Slight.	Slight.	0.40	None.	Faintly vegetable.
10815	Tributary of North Brook, ½ mile north of West Berlin.	Aug. 15	Slight.	Slight.	0.40	Decidedly vegetable and mouldy.	Decidedly vegetable.

ASSABET RIVER.

Chemical Examination of Water from the Assabet River and Tributaries above Northborough — Concluded.

[Parts per 100,000.]

Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Organisms per Cubic Centimeter.
			Albuminoid.								
Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.			
5.00	1.80	.0026	.0166	.0140	.0026	.23	.0030	.0000	.3986	1.3	82
5.10	1.55	.0016	.0084	.0062	.0022	.23	.0150	.0001	.1794	1.9	12
6.25	2.15	.0000	.0408	.0186	.0222	.28	.0000	.0000	.3549	1.7	908
3.70	1.75	.0008	.0166	.0142	.0024	.19	.0000	.0000	.4524	0.5	66
5.20	1.90	.0000	.0146	.0102	.0044	.26	.0400	.0001	.2418	1.3	161
2.85	0.90	.0014	.0170	.0154	.0016	.24	.0000	.0001	.4424	0.3	9
3.40	1.05	.0000	.0144	.0118	.0026	.26	.0000	.0001	.3476	0.8	192

The samples were collected during an investigation for a metropolitan water supply for Boston and its suburbs.

Chemical Examination of Water from the Assabet River in Maynard and Acton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1891.														
12871	Sept. 4	V. slight	Slight.	0.65	4.95	1.75	.0024	.0236	.0222	.0014	.38	.0000	.0001	.3927	1.7
12872	Sept. 4	Decided, milky.	Cons., dirty.	0.70	3.20	1.15	.0072	.0416	.0264	.0152	.44	.0000	.0001	.5544	1.8
12873	Sept. 4	Thick, milky.	Heavy.	0.80	14.90	9.10	.0064	.2260	.0928	.1332	.50	.0020	.0001	1.5092	2.3
12874	Sept. 4	Decided, milky.	Cons., black.	–*	11.60	5.20	.0500	.0820	.0585	.0235	.57	.0000	.0001	1.2012	1.8
12875	Sept. 4	Distinct, milky.	Slight, brown.	0.80	8.85	2.90	.0570	.0510	.0450	.0060	.52	.0000	.0000	.7392	1.8

* Too dark to determine.

Odor, of the first sample, distinctly vegetable and mouldy; of the second, faintly disagreeable; of the third, distinctly disagreeable; of the fourth, decided, musty; of the last, distinctly musty and unpleasant. —— The samples were collected as follows: No. 12871, from the river above the dam about half a mile above the Assabet Manufacturing Company in Maynard; No. 12872, from the river just below the Assabet Manufacturing Company; No. 12873, from the river just below the Assabet Manufacturing Company, after suds, etc., had come down from the works; No. 12874, from the river just above the dam of the American Powder Company in Acton; No. 12875, from the river at the dam of the Damon Manufacturing Company.

The samples were collected in connection with an investigation of the pollution of the stream by manufacturing refuse.

ASSABET RIVER.

Microscopical Examination of Water from the Assabet River in Maynard and Acton.

[Number of organisms per cubic centimeter.]

	1894.				
	Sept.	Sept.	Sept.	Sept.	Sept.
Day of examination,	6	6	6	6	6
Number of sample,	12871	12872	12873	12874	12875
PLANTS.					
Diatomaceæ,	**2**	**1**	**0**	**0**	**19**
Cyclotella,	1	0	0	0	0
Epithemia,	0	0	0	0	1
Synedra,	0	1	0	0	4
Tabellaria,	1	0	0	0	14
Algæ,	**39**	**8**	**0**	**50**	**13**
Cosmarium,	1	0	0	0	0
Hyalotheca,	28	0	0	0	0
Protococcus,	10	8	0	0	8
Scenedesmus,	0	0	0	50	1
Staurastrum,	0	0	0	0	1
Staurogenia,	0	0	0	0	2
Zoöspores,	0	0	0	0	1
Fungi,	**48**	**1**	**50**	**15**	**116**
Beggiatoa,	0	0	50	0	0
Crenothrix,	48	1	0	15	116
ANIMALS.					
Infusoria,	**591**	**2**	**2,850**	**1,300**	**2**
Cryptomonas,	0	0	0	100	1
Dinobryon cases,	584	0	0	0	0
Mallomonas,	1	1	0	0	0
Monas,	0	1	2,800	1,200	0
Peridinium,	1	0	0	0	0
Trachelomonas,	5	0	0	0	1
Vorticella,	0	0	50	0	0
Miscellaneous, Zoöglœa,	**104**	**600**	**4,400**	**2,000**	**216**
TOTAL,	784	612	7,300	3,365	366

Blackstone River.

The regular monthly examinations of the water of the Blackstone River have been continued, as in previous years, and the results are given in the tables on pages 374–379.

The first two tables contain respectively the results for each calendar year, and for the six months of each year from June to November, from the time when examinations were first begun in June, 1887, to the end of 1894.

The operation of the Worcester Precipitation Works has continued through the year, under the direction of skilled chemists and engineers, and numerous examinations of the sewage and effluent have been made and a thorough report of the operation of the works published. The State Board of Health has made no special examination of the works, but from the very complete statement made in the report of the superintendent of sewers for the year ending Nov. 30, 1894, the following information concerning the operation of the works is taken: —

During the year ending Nov. 30, 1894, an average of 12,500,000 gallons of sewage per day, or a total of about 4,562,000,000 gallons for the year, were treated at the Worcester Precipitation Works, and over 2,100 tons of quicklime were used, making the amount of lime 945 pounds per million gallons of sewage. The sludge removed from the sewage during the year contained 5,620 tons of dry solids. With regard to the results shown by the chemical examinations, the following quotations from the report just referred to will be of interest: —

From the following can be seen and compared the percentages of impurity for the year 1894 and five months of 1893: —

Per Cent. Organic Matter Removed from Sewage.

	1893.	1894.	Per Cent. Improvement.
Total amount (by evaporation),	50.88	49.35	3.01
Amount in suspension (by evaporation),	90.67	94.45	4.17
Total amount (by albuminoid ammonia),	48.49	50.79	4.76
Total amount (by oxygen consumed),	33.65	43.84	30.28

BLACKSTONE RIVER.

These results are obtained from daily analyses of samples composed of twenty-four portions, one taken every hour, and consequently give a fair idea of the result of every sixty minutes' work in the 365 days of 1894. Thus the results of the operation of the plant under unfavorable as well as favorable circumstances are tabulated, and the general efficiency of the plant noted therefrom, which seems to be the only fair way of judging of any such work. The nearness with which the results of these two years agree is remarkable, and they would seem to show that the grade of work has been raised during the past year, as the figures for 1894 include the winter and spring months, which bring low results on account of the dilution of the sewage, while those of last year include only the driest season, from July to December.

The following table contains the monthly averages of complete analyses of sewage and effluent and the per cent. removed by treatment: —

WORCESTER SEWAGE PURIFICATION WORKS.

Abstract of Analyses of Sewage and Effluent.

[Parts per 100,000.]

DATE OF COLLECTION.	Residue on Evaporation.									Ammonia.				Oxygen Consumed.		
	Total Residue.			Volatile Residue.			Fixed Residue.				Albuminoid.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.	Chlorine.
Sewage, December, 1893,	45.4	29.9	15.5	17.6	8.6	9.0	27.8	21.3	6.5	1.117	.403	.228	.175	3.55	1.53	5.12
Effluent, December, 1893,	41.8	40.4	1.4	11.3	10.8	0.5	30.5	29.6	0.9	.969	.202	.164	.038	2.88	2.67	5.03
Per cent. removed,	7.93	-35.12	90.97	35.80	-25.58	94.45	-9.79	-38.96	86.16	13.25	49.87	28.07	78.29	18.88	-74.50	1.76
Sewage, January, 1894,	52.8	33.8	19.0	23.3	11.6	11.7	29.5	22.2	7.3	1.217	.555	.287	.268	5.37	2.93	5.18
Effluent, January, 1894,	43.2	41.4	1.8	11.6	11.0	0.6	31.6	30.4	1.2	1.078	.292	.240	.052	3.29	3.01	5.44
Per cent. removed,	18.19	-22.49	90.51	50.21	5.17	94.86	-7.12	-36.93	83.56	11.42	47.40	16.38	80.61	38.74	2.73	-5.02
Sewage, February, 1894,	49.7	32.5	17.2	21.0	10.5	10.5	28.7	22.0	6.7	.990	.468	.241	.227	4.62	2.25	5.51
Effluent, February, 1894,	41.6	40.5	1.1	11.1	10.5	0.6	30.5	30.0	0.5	.902	.245	.216	.029	2.89	2.61	5.17
Per cent. removed,	16.29	24.61	93.61	47.14	0.00	94.28	-2.85	-36.37	92.53	8.89	47.65	10.37	87.24	37.44	-16.00	6.17
Sewage, March, 1894,	42.2	28.1	14.1	15.6	8.7	6.9	26.6	19.4	7.2	.578	.293	.147	.146	3.43	2.03	3.77
Effluent, March, 1894,	35.9	34.8	1.1	9.6	9.2	0.4	26.3	25.6	0.7	.547	.157	.142	.015	2.24	2.07	3.77
Per cent. removed,	14.93	-23.84	92.19	38.46	-5.75	94.21	1.13	-31.96	90.28	5.36	45.63	3.40	89.73	34.69	-1.97	0.00
Sewage, April, 1894,	45.1	28.7	16.4	16.7	9.7	7.0	28.4	19.0	9.4	.618	.347	.185	.162	3.77	2.12	3.62
Effluent, April, 1894,	36.1	33.9	2.2	10.7	9.8	0.9	25.4	24.1	1.3	.576	.211	.177	.034	2.39	2.13	3.56
Per cent. removed,	19.95	-18.11	86.60	35.93	-1.03	87.14	10.52	-26.84	86.18	6.80	39.19	4.32	79.02	36.61	-.47	.59
Sewage, May, 1894,	56.0	33.9	22.1	20.9	12.0	8.9	35.1	21.9	13.2	.935	.415	.198	.217	4.82	2.53	5.06
Effluent, May, 1894,	43.1	40.7	2.4	11.9	11.2	0.7	31.2	29.5	1.7	.871	.220	.185	.035	2.74	2.52	5.03
Per cent. removed,	23.03	-20.05	89.15	43.06	6.67	92.12	11.11	-34.70	87.12	7.06	46.90	6.56	83.87	43.16	.40	.59
Sewage, June, 1894,	55.1	37.8	17.3	22.3	13.2	9.1	32.8	24.6	8.2	1.069	.474	.224	.250	4.46	2.29	5.82
Effluent, June, 1894,	44.0	42.9	1.1	11.4	10.9	0.5	32.6	32.0	0.6	.952	.238	.207	.031	2.22	2.06	5.74
Per cent. removed,	20.41	-13.49	93.44	48.88	17.42	94.52	.61	-30.08	88.18	10.94	49.78	7.59	87.60	50.23	10.04	1.38

Sewage, July, 1894,	92.8	40.5	52.3	26.9	13.6	13.3	65.9	26.9	39.0	1.270	.588	.287	.301	5.86	2.89	6.64
Effluent, July, 1894,	49.9	47.1	2.8	12.9	12.3	0.6	37.0	34.8	2.2	1.062	.299	.273	.026	2.98	2.69	6.76
Per cent. removed,	46.24	-16.29	94.64	52.04	9.56	95.48	43.85	-29.36	94.84	16.39	48.98	4.88	91.35	49.15	6.92	-1.81
Sewage, August, 1894,	65.0	41.1	23.9	26.9	13.8	13.1	38.1	27.3	10.8	1.227	.637	.302	.335	6.14	3.12	6.89
Effluent, August, 1894,	51.3	49.4	1.9	12.5	12.0	0.5	38.8	37.4	1.4	1.088	.300	.283	.017	3.24	2.98	6.95
Per cent. removed,	21.08	-20.19	92.04	53.53	13.04	96.18	-1.84	-38.00	87.04	11.33	52.90	6.29	94.64	47.23	4.49	-.87
Sewage, September, 1894,	76.1	44.2	31.9	28.4	14.9	13.5	47.7	29.3	18.4	1.291	.681	.343	.338	5.85	3.04	6.88
Effluent, September, 1894,	52.7	49.6	3.1	12.8	12.1	0.7	39.9	37.5	2.4	1.126	.305	.287	.018	2.91	2.73	6.86
Per cent. removed,	30.75	-12.22	90.28	54.93	18.79	94.82	16.35	-27.99	86.96	12.78	55.22	16.32	94.66	50.24	10.20	0.29
Sewage, October, 1894,	77.4	49.7	27.7	33.2	16.5	16.7	44.2	33.2	11.0	1.446	.684	.296	.388	6.21	3.37	6.95
Effluent, October, 1894,	53.9	52.9	1.0	12.5	12.1	0.4	41.4	40.8	0.6	1.227	.272	.262	.010	2.78	2.62	6.94
Per cent. removed,	30.37	-6.44	96.38	62.36	26.67	97.61	6.34	-21.69	94.54	15.15	59.66	11.49	97.43	55.24	22.36	0.14
Sewage, November, 1894,	66.8	47.9	18.9	26.8	17.3	9.5	40.0	30.6	9.4	1.107	.522	.237	.285	5.31	3.09	6.47
Effluent, November, 1894,	52.2	50.4	1.8	12.8	12.3	0.5	39.4	38.1	1.3	.952	.250	.234	.016	2.69	2.51	6.41
Per cent. removed,	21.86	-5.22	90.46	52.24	2.89	94.73	1.25	-23.52	86.18	14.01	52.14	1.27	91.20	49.27	18.77	0.93
Sewage for year ending Dec. 1, 1894,	60.4	37.4	23.0	23.3	12.5	10.8	37.1	24.9	12.2	1.073	.506	.248	.258	4.95	2.60	5.66
Effluent for year ending Dec. 1, 1894,	45.5	43.7	1.8	11.8	11.2	0.6	33.7	32.5	1.2	.946	.249	.222	.027	2.78	2.55	5.64
Per cent. removed,	24.67	-16.85	92.17	49.35	10.42	94.45	9.16	-30.52	90.16	11.84	50.78	10.48	89.54	43.84	19.23	0.35

BLACKSTONE RIVER.

Averages of Chemical Analyses of Water from the Blackstone River for the Years 1888 to 1894, inclusive.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
					Albuminoid.						
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
1888, ...	0.64	–	–	.2112	.1040	–	–	1.21	.0370	.0029	–
1889, ...	0.76	–	–	.2841	.1198	.0629	.0569	1.06	.0235	.0024	–
1890, ...	0.82	–	–	.1800	.1024	.0549	.0475	1.03	.0367	.0014	–
1891, ...	0.80	13.54	4.00	.3340	.1563	.0840	.0723	1.73	.0333	.0032	4.6
1892, ...	0.71	16.28	4.85	.2530	.1262	.0627	.0635	1.84	.0312	.0061	4.9
1893, ...	0.68	17.95	4.88	.1429	.0603	.0325	.0277	1.04	.0180	.0012	4.5
1894, ...	0.86	17.17	5.58	.0739	.0570	.0304	.0266	0.88	.0195	.0006	3.7

Blackstone River below Sewage Precipitation Works.

1888, ...	0.64	–	–	.2112	.1040	–	–	1.21	.0370	.0029	–
1889, ...	0.76	–	–	.2841	.1198	.0629	.0569	1.06	.0235	.0024	–
1890, ...	0.74	–	–	.2253	.1177	.0581	.0596	1.26	.0381	.0016	–
1891, ...	0.80	15.62	4.52	.4080	.1303	.0695	.0608	1.91	.0358	.0031	4.6
1892, ...	0.53	19.35	5.29	.3633	.1442	.0737	.0705	2.21	.0278	.0033	7.2
1893, ...	0.74	25.65	6.54	.3757	.1447	.0864	.0583	1.98	.0369	.0070	7.4
1894, ...	0.60	25.75	6.61	.4228	.1309	.0946	.0363	2.13	.0316	.0047	7.9

Blackstone River at Uxbridge.

1888, ...	0.45	–	–	.0979	.0284	–	–	0.61	.0322	.0008	–
1889, ...	0.28	–	–	.0902	.0300	.0191	.0109	0.60	.0253	.0009	–
1890, ...	0.25	–	–	.1168	.0214	.0152	.0062	0.66	.0272	.0006	–
1891, ...	0.27	8.32	1.94	.1647	.0272	.0197	.0075	0.77	.0396	.0008	2.8
1892, ...	0.21	8.59	1.90	.2113	.0222	.0153	.0069	0.82	.0326	.0007	2.8
1893, ...	0.40	9.45	1.91	.1603	.0256	.0167	.0089	1.00	.0424	.0029	3.2
1894, ...	0.51	10.80	1.97	.1372	.0242	.0187	.0055	1.22	.0460	.0032	4.0

Blackstone River at Millville.

1888, ...	0.47	–	–	.0444	.0253	–	–	0.44	.0242	.0005	–
1889, ...	0.38	–	–	.0450	.0277	.0206	.0071	0.43	.0160	.0004	–
1890, ...	0.34	–	–	.0587	.0211	.0162	.0049	0.46	.0240	.0004	–
1891, ...	0.32	6.05	1.83	.0807	.0293	.0194	.0099	0.55	.0275	.0005	1.9
1892, ...	0.35	6.03	1.62	.0896	.0249	.0180	.0069	0.54	.0218	.0004	1.8
1893, ...	0.40	6.23	1.53	.0899	.0288	.0225	.0063	0.66	.0289	.0008	2.0
1894, ...	0.49	6.37	1.90	.0528	.0219	.0173	.0046	0.73	.0232	.0008	2.5

BLACKSTONE RIVER.

AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER FOR SIX MONTHS FROM JUNE TO NOVEMBER, INCLUSIVE, OF EACH YEAR FROM 1887 TO 1894.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887,	0.91	–	–	.2686	.1741	–	–	1.35	.0160	–	–
" " 1888,	0.76	–	–	.2658	.1112	.0557	.0555	1.50	.0382	.0041	–
" " 1889,	0.86	–	–	.3980	.1430	.0772	.0658	1.32	.0177	.0026	–
" " 1890,	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
" " 1891,	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0
" " 1892,	0.52	20.75	6.30	.3547	.1433	.0708	.0725	2.43	.0227	.0108	6.1
" " 1893,	0.40	16.98	4.55	.1480	.0588	.0240	.0348	1.01	.0115	.0015	6.3
" " 1894,	0.66	16.93	4.76	.0548	.0380	.0236	.0144	0.74	.0115	.0005	4.4
Blackstone River below Sewage Precipitation Works.											
June-Nov., 1887,	0.91	–	–	.2686	.1741	.–	–	1.35	.0160	–	–
" " 1888,	0.76	–	–	.2658	.1112	.0557	.0555	1.50	.0382	.0041	–
" " 1889,	0.86	–	–	.3980	.1430	.0772	.0658	1.32	.0177	.0026	–
" " 1890,	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891,	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892,	0.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3
" " 1893,	0.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9
" " 1894,	0.40	29.30	5.86	.6189	.1390	.1113	.0277	2.63	.0212	.0071	10.6
Blackstone River at Uxbridge.											
June-Nov., 1887,	0.39	–	–	.1129	.0271	–	–	0.79	.0360	–	–
" " 1888,	0.38	6.42	1.52	.1155	.0288	.0222	.0066	0.68	.0310	.0007	–
" " 1889,	0.32	–	–	.1133	.0296	.0192	.0104	0.66	.0333	.0009	–
" " 1890,	0.26	8.86	2.12	.1629	.0231	.0174	.0057	0.79	.0259	.0005	2.9
" " 1891,	0.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6
" " 1892,	0.13	9.36	1.88	.2840	.0227	.0162	.0065	0.99	.0313	.0007	3.1
" " 1893,	0.24	11.74	2.37	.1985	.0207	.0140	.0067	1.20	.0623	.0050	4.2
" " 1894,	0.35	13.07	2.03	.1456	.0243	.0183	.0060	1.57	.0673	.0050	4.9
Blackstone River at Millville.											
June-Nov., 1887,	0.31	–	–	.0468	.0220	–	–	0.51	.0210	–	–
" " 1888,	0.41	5.22	1.40	.0467	.0296	.0233	.0063	0.50	.0278	.0004	–
" " 1889,	0.38	–	–	.0499	.0273	.0213	.0060	0.45	.0167	.0003	–
" " 1890,	0.26	6.71	2.24	.0736	.0196	.0152	.0044	0.53	.0229	.0003	2.3
" " 1891,	0.24	7.48	2.35	.1105	.0384	.0234	.0150	0.72	.0308	.0006	2.2
" " 1892,	0.37	6.70	1.62	.1143	.0294	.0210	.0084	0.63	.0217	.0002	2.0
" " 1893,	0.23	7.43	1.73	.0677	.0119	.0087	.0031	0.77	.0385	.0011	2.6
" " 1894,	0.47	8.42	2.16	.0510	.0172	.0139	.0033	0.89	.0273	.0012	2.8

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River, between Mill

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance.			Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
			Turbidity.	Sediment.	Color.	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.
		1894.									
1	11644	Jan. 16	Thick.	Heavy, dark.	1.10	35.20	13.00	22.20	12.20	5.40	6.80
2	11757	Feb. 13	Decided.	Heavy, dark.	0.80	12.20	10.00	2.20	4.60	3.00	1.60
3	11883	Mar. 13	Decided.	Heavy, gray.	1.20	10.60	8.20	2.40	3.60	2.60	1.00
4	12072	Apr. 17	Decided.	Cons.	1.60	13.20	6.60	6.60	4.80	1.00	3.80
5	12224	May 15	Decided.	Heavy, rusty.	0.30	17.20	10.80	6.40	8.40	4.40	4.00
6	12399	June 19	Decided.	Heavy, rusty.	0.90	30.20	25.00	5.20	12.40	10.30	2.10
7	12560	July 17	Distinct, yellow.	Cons., rusty.	1.10	12.20	9.00	3.20	–	–	–
8	12749	Aug. 14	Decided, milky.	Heavy, rusty.	1.10	12.20	7.90	4.30	2.40	2.10	0.30
9	12974	Sept. 18	Decided.	Heavy, rusty.	0.12	16.00	13.00	3.00	3.20	3.10	0.10
10	13154	Oct. 17	Distinct, milky.	Cons., rusty.	0.05	17.20	16.40	0.80	3.80	3.60	0.20
11	13348	Nov. 20	Decided.	Heavy, brown.	0.68	13.80	10.60	3.20	2.00	1.20	0.80
12	13513	Dec. 18	Decided.	Cons., rusty.	1.40	16.00	12.20	3.80	4.00	2.20	1.80
13	Av.	....	....	....	0.86	17.17	11.89	5.28	5.58	3.54	2.04

Odor, offensive. —— The samples were collected from the river about 200 feet below the iron bridge. No. 13154 was collected on Wednesday and the remaining samples on Tuesday. The samples were collected at various hours between 8.20 A.M. and 3.20 P.M.

Chemical Examination of Water from Blackstone

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance.			Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
			Turbidity.	Sediment.	Color.	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.
		1894.									
1	11645	Jan. 16	Thick.	Heavy, dark.	1.20	36.00	18.40	17.60	10.20	5.20	5.00
2	11758	Feb. 13	Decided.	Heavy, gray.	0.55	17.20	13.20	4.00	5.40	2.60	2.80
3	11884	Mar. 13	Distinct.	Heavy, rusty.	0.40	16.40	10.60	5.80	5.60	2.80	2.80
4	12073	April 17	Decided.	Cons.	1.80	14.20	10.40	3.80	4.40	2.60	1.80
5	12225	May 15	Decided.	Heavy, rusty.	0.58	17.60	12.40	5.20	8.00	3.20	4.80
6	12400	June 19	Decided.	Cons., brown.	0.70	18.90	15.40	3.50	4.00	2.80	1.20
7	12561	July 17	Decided, yellow.	Cons., rusty.	0.30	16.20	12.70	3.50	–	–	–
8	12750	Aug. 14	Decided, milky.	Cons., yellow.	0.30	39.70	38.70	1.00	6.30	6.30	0.00
9	12975	Sept. 18	Decided.	Heavy, brown.	0.70	32.40	29.20	3.20	5.40	5.20	0.20
10	13155	Oct. 17	Distinct, milky.	Cons., rusty.	0.10	41.40	39.20	2.20	8.20	7.20	1.00
11	13349	Nov. 20	Decided.	Heavy, brown.	0.30	27.20	24.80	2.40	5.40	5.40	0.00
12	13514	Dec. 18	Decided.	Heavy, brown.	0.27	31.80	23.60	8.20	9.80	6.20	3.60
13	Av.	....	....	....	0.60	25.75	20.72	5.03	6.61	4.50	2.11

Odor, offensive. —— The samples were collected from the river above Millbury and below the point where the effluent from the Worcester Precipitation Works enters the river. No. 13155 was collected on Wednesday and the remaining samples on Tuesday. The samples were collected at various hours between 8.30 A.M. and 3.25 P.M.

BLACKSTONE RIVER.

Brook Channel and the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Iron.		Hardness.	
	Albuminoid.									
Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.		
.2560	.1940	.0940	.1000	1.41	.0150	.0002	1.1400	.1300	2.9	1
.1280	.0790	.0400	.0390	1.24	.0450	.0008	.8200	.1960	2.5	2
.0800	.0520	.0320	.0200	.80	.0300	.0009	.4900	.2800	1.7	3
.0480	.0570	.0230	.0340	.83	.0250	.0008	.7300	.3600	1.7	4
.0160	.0370	.0110	.0260	.70	.0200	.0001	2.0800	1.3600	5.9	5
.0520	.0290	.0170	.0120	.99	.0030	.0001	8.8900	6.0000	10.1	6
.0384	.0370	.0214	.0156	.61	.0060	.0009	.8200	.1350	1.9	7
.1200	.0760	.0530	.0230	.49	.0050	.0004	.7000	.2000	2.2	8
.0368	.0304	.0168	.0136	.60	.0050	.0004	.4700	.0650	3.1	9
.0480	.0250	.0190	.0060	1.15	.0200	.0006	.4400	.3600	6.4	10
.0336	.0308	.0146	.0162	.61	.0300	.0009	.9000	.2700	3.0	11
.0304	.0372	.0236	.0136	1.25	.0300	.0011	.9200	.4800	3.5	12
.0739	.0570	.0304	.0266	.88	.0195	.0006	1.5333	.8197	3.7	13

Microscopical Examination.

No. 12560. No organisms.

No. 13348. Diatomaceæ, *Synedra*, 50. Infusoria, *Monas*, 50. Miscellaneous, *Zoöglœa*, 10,800. Total, 10,900.

The other samples were not examined.

River below the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Iron.		Hardness.	
	Albuminoid.									
Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.		
.4400	.2000	.1160	.0840	2.43	.0320	.0025	.6400	.1900	5.4	1
.2280	.0810	.0450	.0360	1.49	.0550	.0018	.7800	.1260	4.6	2
.1160	.0560	.0290	.0270	1.07	.0200	.0014	1.9600	1.0000	4.6	3
.0920	.0600	.0320	.0280	1.11	.0370	.0015	.7600	.3800	3.1	4
.1560	.0560	.0280	.0280	1.14	.0300	.0022	1.4800	.3200	4.9	5
.2720	.0900	.0540	.0360	1.82	.0100	.0003	.6650	.0500	6.4	6
.1376	.0570	.0326	.0244	1.26	.0000	.0000	.8000	.0540	4.0	7
1.8080	.3410	.3050	.0360	4.60	.0100	.0300	.1500	.0080	14.2	8
.4800	.1270	.0780	.0490	3.44	.0020	.0000	.1600	.0400	11.1	9
.6800	.1280	.1180	.0100	3.62	.0370	.0080	.1740	.0260	17.9	10
.3360	.0910	.0800	.0110	1.05	.0680	.0042	.4200	.1200	10.3	11
.3280	.2840	.2180	.0660	2.56	.0780	.0050	1.2400	.0800	8.7	12
.4228	.1309	.0946	.0363	2.13	.0316	.0047	.7691	.1995	7.9	13

Microscopical Examination.

No. 13349. Infusoria, *Ciliated infusorian*, 100; *Monas*, 100; Miscellaneous, *Zoöglœa*, 3,200. Total, 3,400.

The other samples were not examined.

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River at Uxbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid Total.	Albuminoid Dissolved.	Albuminoid Suspended.		Nitrates.	Nitrites.		
	1894.														
11653	Jan. 18	Distinct, milky.	Slight.	0.70	9.50	2.00	.1320	.0090	.0060	.0030	.88	.0300	.0012	.4708	3.1
11775	Feb. 15	Decided, milky.	Slight, rusty.	0.70	9.60	2.00	.2080	.0320	.0260	.0060	1.11	.0220	.0015	.3240	3.6
11898	Mar. 15	Slight, milky.	Slight.	0.73	5.20	1.40	.0608	.0206	.0172	.0034	.52	.0300	.0008	.3816	1.8
12065	Apr. 17	Decided.	Cons.	0.90	6.00	1.10	.0480	.0240	.0170	.0070	.56	.0130	.0007	.3588	1.9
12235	May 17	Decided.	Cons.	0.30	8.30	2.00	.0840	.0220	.0170	.0050	.79	.0350	.0025	.3081	2.9
12413	June 21	Distinct, milky.	Slight, fibrous.	0.60	8.30	2.00	.0810	.0170	.0130	.0040	.90	.0280	.0100	.2364	3.2
12582	July 19	Distinct.	Slight, rusty.	0.28	10.65	1.45	.0142	.0222	.0192	.0030	1.32	.0900	.0040	.4081	3.8
12766	Aug. 6	Slight.	Cons., rusty.	0.40	11.20	1.75	.0680	.0220	.0130	.0090	1.43	.0800	.0050	.3080	4.4
13000	Sept. 20	V. slight.	Cons.	0.12	15.00	1.90	.0784	.0188	.0158	.0030	1.94	.0980	.0066	.2849	5.6
13167	Oct. 18	Distinct, milky.	Slight.	0.15	18.30	3.00	.3040	.0300	.0200	.0100	2.24	.0700	.0032	.3436	6.7
13350	Nov. 21	Slight.	Slight.	0.58	15.00	2.10	.3280	.0360	.0290	.0070	1.60	.0380	.0013	.4719	5.7
13533	Dec. 20	Distinct, milky.	Slight.	0.60	12.60	2.90	.2400	.0370	.0310	.0060	1.32	.0180	.0012	.4543	4.7
Av.	....	....	....	0.51	10.80	1.97	.1372	.0242	.0187	.0055	1.22	.0460	.0032	.3625	4.0

Iron, determined after water had been filtered through filter-paper, .0884. Odor, generally musty, occasionally disagreeable or offensive. —— The samples were collected from the canal leading from the upper dam of the Calumet Woolen Company to the mill, just before the water passed the screens.

Microscopical Examination.

The number of organisms found in these samples varied from 185 to 2,450 per cubic centimeter, and averaged 926, Zoöglœa being generally the most abundant, and averaging 618.

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River at Millville, Blackstone.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11652	Jan. 18	Distinct, milky.	Slight.	0.60	6.30	1.10	.0680	.0100	.0060	.0040	.59	.0180	.0004	.4345	2.7
11776	Feb. 15	Distinct, milky.	Cons., rusty.	0.50	6.30	1.80	.1280	.0470	.0340	.0130	.69	.0220	.0005	.4240	2.6
11899	Mar. 15	Slight, milky.	V. slight.	0.65	4.80	1.40	.0344	.0192	.0174	.0018	.40	.0180	.0005	.4480	1.6
12074	Apr. 19	Distinct.	Cons.	0.63	5.00	1.60	.0384	.0222	.0190	.0032	.46	.0250	.0003	.3978	1.7
12237	May 17	Distinct.	Cons.	0.08	5.80	2.00	.0268	.0192	.0136	.0056	.52	.0170	.0008	.3861	1.9
12412	June 21	Slight, milky.	Slight, rusty.	0.65	7.90	2.10	.0540	.0210	.0160	.0050	.75	.0450	.0030	.3912	2.9
12587	July 19	Distinct.	Slight, yellow.	0.30	7.20	3.10	.0056	.0184	.0152	.0032	.74	.0200	.0004	.3080	2.2
12768	Aug. 16	Slight, milky.	Slight.	0.48	7.70	1.60	.0042	.0188	.0154	.0034	.83	.0300	.0005	.3234	2.4
13005	Sept. 20	Slight, milky.	Slight.	0.45	7.80	1.75	.0296	.0150	.0136	.0014	.89	.0320	.0013	.3349	2.7
13171	Oct. 18	Slight, milky.	Slight.	0.28	9.40	1.80	.1120	.0210	.0160	.0050	1.10	.0200	.0014	.3555	3.2
13357	Nov. 21	Distinct.	Slight.	0.65	10.50	2.60	.1440	.0260	.0200	.0060	1.04	.0170	.0007	.4992	3.6
13535	Dec. 20	Distinct, milky.	Slight.	0.63	7.80	2.00	.1320	.0420	.0340	.0080	.72	.0150	.0003	.5390	2.9
Av.	....	....	....	0.49	6.37	1.90	.0647	.0233	.0183	.0050	.73	.0232	.0008	.4035	2.5

Iron, determined after water had been filtered through filter-paper, .0506. Odor, musty and occasionally disagreeable or offensive. —— The samples were collected from the river just above the dam in the village of Millville.

Microscopical Examination.

The number of organisms found in these samples varied from 119 to 1,502 per cubic centimeter and averaged 550, Zoöglœa being generally the most abundant and averaging 248.

CHARLES RIVER.

Charles River.

Chemical Examination of Water from the Charles River at South Natick.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11679	Jan. 24	V. slight.	V. slight.	0.80	4.75	1.65	.0004	.0124	.0110	.0014	.40	.0090	.0000	.7450	1.4
11728	Feb. 7	Slight.	Slight.	0.75	4.85	1.60	.0026	.0210	.0186	.0024	.41	.0120	.0001	.7640	1.3
11830	Mar. 1	Slight.	Slight.	0.85	4.30	1.60	.0008	.0174	.0156	.0018	.36	.0050	.0000	.7984	1.3
12154	May 3	V. slight.	Slight.	1.20	4.30	2.20	.0008	.0238	.0206	.0032	.36	.0000	.0000	.9376	0.9
12240	May 16	Slight.	Slight.	1.20	3.95	1.95	.0010	.0220	.0202	.0018	.31	.0000	.0000	.7426	1.3
12306	June 4	V. slight.	Slight.	1.55	4.75	2.45	.0014	.0296	.0280	.0016	.28	.0030	.0000	1.2074	1.3
12465	July 2	None.	Slight.	0.85	4.15	1.85	.0004	.0230	.0212	.0018	.33	.0000	.0000	.7084	1.6
12669	Aug. 6	V. slight.	V. slight.	0.60	4.35	1.50	.0016	.0214	.0192	.0022	.49	.0040	.0000	.5505	1.1
12881	Sept. 4	Slight.	Slight.	0.50	5.65	2.00	.0000	.0208	.0200	.0008	.48	.0000	.0001	.4697	1.4
13049	Oct. 1	Slight.	Slight.	0.45	5.25	1.55	.0000	.0194	.0164	.0030	.60	.0000	.0000	.4858	1.3
13247	Nov. 1	Slight.	V. slight.	1.20	6.15	3.10	.0012	.0294	.0272	.0022	.71	.0030	.0000	1.0164	1.8
13424	Dec. 3	V. slight.	V. slight.	1.25	5.65	2.40	.0004	.0194	.0172	.0022	.43	.0070	.0000	.9586	1.7
Av.	....	....	....	0.93	4.84	1.99	.0009	.0216	.0196	.0020	.43	.0036	.0000	.7820	1.4

Odor, vegetable and frequently also mouldy. —— The samples were collected from the river above the dam at South Natick. The samples were collected in connection with an investigation for a metropolitan water supply for Boston and its suburbs.

Microscopical Examination.

Average number of organisms, 70 per cubic centimeter.

Deerfield River.

The reply of the State Board of Health to the town of Deerfield with reference to the pollution of the Green River, a tributary of the Deerfield River in that town, may be found on pages 63 and 64 of this volume. The results of examinations of samples of water collected from the Deerfield and Green Rivers in connection with the investigation of the pollution of the latter stream are given in tables on pages 381 and 382.

The results of examinations of the Deerfield River at Shelburne Falls made in connection with the investigations for a metropolitan water supply for Boston and its suburbs are given below.

DEERFIELD RIVER.

Chemical Examination of Water from the Deerfield River above Shelburne Falls.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
11630	Jan. 12	None.	V. slight.	0.15	3.35	0.95	.0000	.0058	.0046	.0012	.08	.0150	.0000	.2270	1.4
11829	Mar. 1	Distinct.	Slight.	0.10	3.50	1.00	.0000	.0074	.0062	.0012	.11	.0090	.0000	.2520	1.6
12186	May 10	Slight.	Slight.	0.48	3.25	1.45	.0006	.0154	.0140	.0014	.11	.0000	.0000	.5453	1.7
12444	June 28	None.	V. slight.	0.45	4.05	1.25	.0000	.0142	.0126	.0016	.13	.0030	.0000	.4173	1.7
12480	July 5	V. slight.	Slight.	0.30	3.60	0.65	.0006	.0132	.0118	.0014	.16	.0000	.0000	.3480	2.0
12670	Aug. 6	V. slight.	Slight.	0.50	3.70	0.95	.0004	.0158	.0142	.0016	.13	.0000	.0000	.4697	1.4
12876	Sept. 4	V. slight.	V. slight.	0.18	4.10	1.10	.0012	.0094	.0084	.0010	.24	.0000	.0000	.2387	1.9
13283	Nov. 7	V. slight.	Slight.	0.65	3.40	1.20	.0000	.0108	.0084	.0024	.11	.0030	.0000	.6583	1.4
13456	Dec. 6	V. slight	Slight.	0.28	3.75	1.15	.0014	.0078	.0066	.0012	.11	.0150	.0002	.3542	1.9
Av.	....	....	....	0.34	3.63	1.08	.0005	.0111	.0096	.0015	.13	.0050	.0000	.3901	1.7

Odor, faintly vegetable or none, becoming somewhat stronger on heating. —— The samples were collected from the river, about a mile above the bridge in the village of Shelburne Falls, in connection with an investigation for a metropolitan water supply for Boston and its suburbs.

Microscopical Examination.

Average number of organisms, 65 per cubic centimeter.

Chemical Examination of Water from the Deerfield River at Deerfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
12932	Sept. 10	V. slight.	V. slight.	0.18	4.95	1.15	.0012	.0096	.0076	.0020	.16	.0030	.0000	.1617	2.7
12933	Sept. 10	V. slight.	V. slight, brown.	0.10	5.50	1.35	.0078	.0102	.0088	.0014	.20	.0030	.0010	.1463	2.9

Odor, none. —— The first sample was collected from the Deerfield River just above the mouth of the Green River; the second from the Deerfield River below the Green River, under the bridge of the Connecticut River Railroad.

Microscopical Examination.

No. 12932. Diatomaceæ, *Cymbella*, 2; *Pinnularia*, 2; *Synedra*, 12; *Tabellaria*, 1. Cyanophyceæ, *Microcystis*, 1. Algæ, *Hyalotheca*, 8; *Nephrocytium*, 2. Fungi, *Crenothrix*, 8; *Molds*, 2. Infusoria, *Peridinium*, 3. Miscellaneous, *Zoöglœa*, 56. Total, 97.

No. 12933. Diatomaceæ, *Cymbella*, 7; *Navicula*, 1; *Synedra*, 1. Algæ, *Pediastrum*, 1; *Scenedesmus*, 2. Fungi, *Crenothrix*, 100. Infusoria, *Peridinium*, 5; *Trachelomonas*, 1. Total, 118.

DEERFIELD RIVER.

Chemical Examination of Water from the Green River in Greenfield and Deerfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1894.														
12930	Sept.10	V. slight.	V. slight.	0.01	7.85	1.50	.0008	.0028	.0022	.0006	.09	.0020	.0000	.0231	4.7
12931	Sept.10	Slight.	Cons., brown.	0.10	8.15	1.90	.0416	.0154	.0114	.0040	.30	.0050	.0040	.1001	4.7

Odor, of the first sample, none; of the second, distinctly vegetable.——The first sample was collected from Green River just above Mill River in Greenfield; the last from Green River just above its outlet into Deerfield River in Deerfield.

Microscopical Examination.

No. 12930. Diatomaceæ, *Cymbella*, 4; *Diatoma*, 2; *Pinnularia*, 3; *Synedra*, 9. Algæ, *Scenedesmus*, 1. Fungi, *Crenothrix*, 28. Miscellaneous, *Zoöglœa*, 44. Total, 91.

No. 12931. Diatomaceæ, *Cocconeis*, 1; *Diatoma*, 4; *Navicula*, 10; *Pinnularia*, 1; *Synedra*, 3; *Tabellaria*, 2. Algæ, *Pediastrum*, 5; *Scenedesmus*, 9; *Selenastrum*, 6. Fungi, *Crenothrix*, 420. Rhizopoda, *Amœba*, 2. Infusoria, *Euglena*, 1; *Monas*, 1. Vermes, *Anguillula*, 1. Miscellaneous, *Zoöglœa*, 200. Total, 666.

Hoosac River.

Regular monthly examinations of the water of this river have been made during the year 1894 with a view to determining the extent to which it is polluted by sewage and manufacturing wastes from the towns and villages on its water-shed. The samples were collected at Williamstown about five miles below North Adams, the largest town on the water-shed. Regular monthly examinations of the river were made in the years 1887 to 1889, and the average results obtained in those years are given in the table of averages by years following the analyses of 1894.

HOOSAC RIVER.

Chemical Examination of Water from the Hoosac River at Williamstown.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11671	Jan. 23	Distinct.	Cons., white.	0.02	10.45	1.70	.0026	.0108	.0076	.0032	.28	.0300	.0002	.3278	7.6
11738	Feb. 10	Distinct, milky.	Cons., gray.	0.05	10.70	1.45	.0004	.0304	.0162	.0142	.37	.0300	.0009	.2744	7.4
11875	Mar. 12	Distinct.	Cons., gray.	0.10	4.90	0.90	.0022	.0152	.0130	.0022	.08	.0120	.0002	.2560	3.2
12048	Apr. 16	V. slight.	Cons.	0.12	6.00	1.20	.0062	.0128	.0074	.0054	.17	.0120	.0004	.1920	4.2
12216	May 14	Slight.	Cons.	0.20	9.00	1.70	.0164	.0184	.0130	.0054	.20	.0150	.0005	.2301	6.9
12381	June 18	Decided.	Cons.	0.30	13.00	2.25	.0124	.0490	.0250	.0240	.40	.0070	.0016	.3704	8.7
12548	July 15	Distinct.	Cons., brown.	0.30	15.90	4.00	.0222	.0330	.0266	.0064	.54	.0080	.0015	.4166	10.3
12752	Aug. 14	Distinct.	Cons., brown.	0.35	17.55	2.55	.0350	.0332	.0278	.0054	.69	.0100	.0008	.3734	11.6
12979	Sept. 18	Slight, milky.	Cons., gray.	0.45	15.90	3.40	.0228	.0386	.0242	.0144	.72	.0050	.0030	.4081	10.6
13147	Oct. 17	Slight.	Slight, gray.	0.50	11.00	2.65	.0004	.0268	.0196	.0072	.39	.0100	.0012	.6438	7.1
13346	Nov. 20	Distinct.	Heavy, gray.	0.30	8.00	1.60	.0070	.0360	.0114	.0246	.24	.0210	.0004	.3276	5.7
13510	Dec. 18	Slight.	Cons., white.	0.12	6.90	2.20	.0052	.0138	.0106	.0032	.17	.0280	.0001	.2849	4.2
Av.	....	....	....	0.23	10.77	2.13	.0111	.0265	.0169	.0096	.35	.0157	.0009	.3421	7.3

Averages by Years.

-	1887*	-	-	0.21	11.50	1.23	.0057	.0178	-	-	.22	.0230	-	-	-
-	1888	-	-	0.10	10.21	1.65	.0040	.0187	.0143	.0044	.24	.0306	.0010	-	-
-	1889†	-	-	0.08	8.74	1.18	.0071	.0162	.0104	.0058	.18	.0254	.0006	-	-
-	1894	-	-	0.23	10.77	2.13	.0111	.0265	.0169	.0096	.35	.0157	.0009	.3421	7.3

* June to December. † January to May.

NOTE to analyses of 1894: Odor, generally decidedly musty, frequently also disagreeable. —— The samples were collected from the river at the bridge near the Williamstown station on the Fitchburg Railroad.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 683 and consisted in most cases chiefly of *Zoöglœa*. The highest number found in any one month was 4,242 in October, consisting almost wholly of *Crenothrix*.

HOUSATONIC RIVER.

HOUSATONIC RIVER.

Chemical Examination of Water from the Housatonic River at New Lenox.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11680	Jan. 24	Slight, milky.	Cons.	0.10	10.30	1.85	.0028	.0074	.0050	.0024	.18	.0280	.0005	.2686	8.0
11803	Feb. 22	Distinct.	Cons.	0.10	9.70	1.25	.0042	.0160	.0118	.0042	.17	.0200	.0003	.2680	7.4
11921	Mar. 19	Slight.	Cons.	0.15	8.10	1.85	.0042	.0144	.0094	.0050	.16	.0200	.0004	.3239	6.3
12075	Apr. 19	Distinct.	Cons.	0.22	9.75	1.75	.0014	.0296	.0160	.0136	.19	.0120	.0003	.3003	7.4
12275	May 22	Distinct.	Cons.	0.25	10.50	1.80	.0132	.0194	.0150	.0044	.17	.0120	.0008	.2847	8.0
12430	June 25	Slight.	Slight, brown.	0.40	12.00	2.50	.0486	.0172	.0148	.0024	.16	.0050	.0025	.2695	8.9
12615	July 25	Slight.	Slight.	0.20	11.35	2.25	.0016	.0168	.0160	.0008	.32	.0200	.0067	.3388	8.3
12797	Aug. 21	Slight.	Slight.	0.33	14.45	2.75	.0166	.0186	.0160	.0026	.48	.0300	.0125	.3426	10.4
13036	Sept. 27	Distinct.	Cons., brown.	0.40	14.00	2.50	.0178	.0258	.0224	.0034	.42	.0400	.0018	.5744	10.0
13200	Oct. 23	Distinct, milky.	Slight, gray.	0.45	14.70	2.90	.0256	.0194	.0174	.0020	.33	.0050	.0025	.4479	10.9
13398	Nov. 27	Distinct, milky.	Slight.	0.30	11.35	1.95	.0146	.0186	.0146	.0040	.24	.0230	.0008	.4182	8.7
13515	Dec. 18	Slight.	Cons., gray.	0.40	10.20	2.20	.0062	.0166	.0148	.0018	.17	.0300	.0002	.3773	7.7
Av.	1894	....	....	0.27	11.37	2.13	.0131	.0183	.0144	.0039	.25	.0204	.0024	.3512	8.5
Av.	1893*	....	....	0.30	9.73	2.21	.0058	.0174	.0134	.0040	.16	.0175	.0014	.4180	7.0

* March to December.

Odor, decidedly musty. —— The samples were collected from the river.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 371, consisting chiefly of *Crenothrix* and *Zoöglœa*. The highest number found was 1,035 in June and consisted chiefly of *Zoöglœa*.

MERRIMACK RIVER.

The usual monthly examinations of the water of this river opposite the intakes of the Lowell and the Lawrence Water Works have been continued during 1894, the detailed results of which may be found on pages 190 and 202 of this volume. A comparison of the analyses made at these two places during the year is given in the following table : —

MERRIMACK RIVER.

Table comparing the Analyses above Lowell with those above Lawrence, 1894.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Number of determinations compared,	12	12	12	12	12	12	12	12	12	12	12
Mean of analyses above Lowell,	0.35	3.55	1.26	.0034	.0135	.0109	.0026	.178	.0063	.0001	1.1
Mean of analyses above Lawrence,	0.37	3.70	1.30	.0062	.0167	.0141	.0026	.227	.0063	.0001	1.2
Increase,	0.02	0.15	0.04	.0028	.0032	.0032	.0000	.049	.0000	.0000	0.1

In order to compare these results with similar ones obtained in previous years, another table is presented, which contains the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years: —

Increase in the Amount of Impurities in the Merrimack River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.

[Parts per 100,000.]

Date.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Increase, 1887-1889,	0.01	0.23	0.09	.0007	.0027	.0017	.0009	.026	.0003*	.0000	–
Increase, 1890,	0.05	0.62	0.22*	0016	.0023	.0017	.0006	.028	.0020*	.0000	0.2
Increase, 1891,	0.02*	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030*	.0000	0.1
Increase, 1892,	0.06	0.48	0.12	.0019	.0037	.0037	.0000	.039	.0013*	.0000	0.0
Increase, 1893,	0.09	0.47	0.30	.0031	.0032	.0021	.0011	.035	.0002*	.0001	0.0
Increase, 1894,	0.02	0.15	0.04	.0028	.0032	.0032	.0000	.049	.0000	.0000	0.1

* Decrease.

The average flow of the river at Lawrence, per twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948, 7,931, 5,433, 8,126 and 6,459 cubic feet per second.

In the following tables are given the results of chemical and bacterial examinations of samples of water collected from the Merrimack River between Lowell and Lawrence on a holiday following a Sunday. They are interesting as showing a condition which may exist in the river.

MERRIMACK RIVER.

Chemical Examination of Water from the Merrimack River at Various Points between Lowell and Lawrence.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.*	Hardness.	Bacteria per Cubic Centimeter.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1894.												
1	Sept. 3	V. slight.	Decided.	.39	Slight.	.0324	.0290	.44	.0088	.0006	.2600	2.2	22,500
2	Sept. 3	V. slight.	Decided.	.32	V. slight.	.0234	.0260	.39	.0092	.0002	.2500	2.2	24,300
3	Sept. 3	V. slight.	Decided.	.27	V. slight.	.0154	.0204	.33	.0088	.0002	.2400	2.0	6,500
4	Sept. 3	V. slight.	Decided.	.29	V. slight.	.0128	.0200	.36	.0076	.0002	.2400	2.0	1,600

* Determined after boiling for two minutes only.

The samples were collected as follows: No. 1 at the foot of Hunt's Falls, 9 miles above the pumping station of the Lawrence water works; No. 2, opposite the mouth of Trull Brook, 5.5 miles above the Lawrence pumping station; No. 3, just below "The Narrows," 4.5 miles above the Lawrence pumping station; No. 4, opposite the Lawrence pumping station.

Bacterial Examination of Water from the Merrimack River at Various Points between Lowell and Lawrence.

Place of Collection.	Depth below Surface.	Bacteria per Cubic Centimeter.		
		Middle of South Half of River.	Middle of River.	Middle of North Half of River.
At foot of Hunt's Falls, 9 miles above Lawrence pumping station,	6 inches.	39,200	22,500	20,700
	8 feet.	42,000	12,700	24,500
Opposite mouth of Trull Brook, 5.5 miles above Lawrence pumping station,	6 inches.	23,700	24,300	31,000
	8 feet.	16,000	18,500	23,200
Just below "The Narrows," 4.5 miles above Lawrence pumping station,	6 inches.	6,600	6,500	6,000
	8 feet.	5,600	9,300	7,500
Above Pine Island, 3.5 miles above Lawrence pumping station,	6 inches.	5,600	5,400	3,000
	8 feet.	4,900	6,500	7,900
Opposite pumping station of Lawrence water works,	6 inches.	1,400	1,600	1,900
	8 feet.	2,200	1,100	1,300

Lake Winnipiseogee.

In connection with the investigations for a metropolitan water supply for Boston and its suburbs examinations were made of the water of this lake at several places, and of the Merrymeeting River, one of its principal tributaries, the water-shed of which comprises about one-eighth of the land surface draining into the lake. The first table given below contains the results of analyses of samples

of water from the Merrymeeting River, which enters an arm of the lake known as Alton Bay, from Alton Bay, and from the main portion of the lake, three-fourths of a mile from Alton Bay. The results of the analysis of the sample of water from the Merrymeeting River, together with other investigations, show that while some of the streams which enter the lake contain water which is far inferior to the water taken from the lake itself, yet the excellent opportunity which the water has in this great lake for bleaching and otherwise becoming purified by storage produces a water which is practically colorless, very soft and contains only a small amount of organic matter.

With a view to learning whether in the deeper portions of the lake there was any accumulation of decomposing organic matter, such as has been found in some cases at the bottom of large lakes and storage reservoirs during the period of stagnation in summer, samples of water were collected, at intervals of 10 feet from the surface to the bottom, at a place where the lake was 110 feet in depth, and the results, given in the table on page 388, show that the water is of practically the same character at the bottom as at the surface. The temperature at the surface at the time the samples were collected was 70.5° F., while the temperature at the bottom was 51.6° F.

Chemical Examination of Water from the Merrymeeting River and Lake Winnipiseogee, New Hampshire.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1894.														
12781	Aug.18	V. slight.	Slight.	0.35	3.05	1.60	.0002	.0156	.0146	.0010	.10	.0000	.0000	.4851	1.1
12779	Aug.18	V. slight.	Slight, white.	0.18	2.60	1.00	.0002	.0106	.0086	.0020	.10	.0000	.0000	.2348	0.7
12780	Aug.18	V. slight.	V. slight.	0.04	2.35	0.75	.0000	.0068	.0068	.0000	.08	.0000	.0000	.1116	0.6

Odor, of the first sample, distinctly vegetable; of the second, faintly vegetable; of the last, none. —— The first sample was collected from the Merrymeeting River at the bridge nearest the lake; the second from Lake Winnipiseogee at Alton Bay in the middle of the channel opposite the ice houses; the third from the lake about 3¾ miles from the head of Alton Bay and about ¾ of a mile beyond Gerrish's Point.

Microscopical Examination.

No. 12781. Total number of organisms, 129.
No. 12779. Total number of organisms, 165.
No. 12780. Total number of organisms, 55.

LAKE WINNIPISEOGEE.

Chemical Examination of Water from Lake Winnipiseogee at Lakeport, New Hampshire, collected at Various Depths.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
10901	Aug.28	V. slight.	V. slight.	0.02	2.15	0.55	.0000	.0084	.0072	.0012	.100	.0000	.0000	.1580	0.8
10902	Aug.28	V. slight.	V. slight, white.	0.02	2.10	0.75	.0000	.0074	.0062	.0012	.100	.0000	.0000	.1738	0.8
10903	Aug.28	Slight.	Slight, white.	0.02	2.10	0.90	.0000	.0088	.0068	.0020	.102	.0000	.0000	.1659	0.8
10904	Aug.28	Slight.	Slight, white.	0.02	2.25	1.00	.0000	.0082	.0064	.0018	.104	.0000	.0000	.1659	0.8
10905	Aug.28	Slight.	Slight, white.	0.02	1.95	0.55	.0000	.0076	.0060	.0016	.106	.0000	.0000	.1659	0.8
10906	Aug.28	V. slight.	V. slight.	0.02	2.50	1.15	.0000	.0072	.0044	.0028	.100	.0000	.0000	.1659	0.8
10907	Aug.28	V. slight.	V. slight.	0.02	2.65	1.55	.0000	.0078	.0042	.0036	.100	.0000	.0000	.1659	0.8
10908	Aug.28	Slight.	Slight, white.	0.02	1.90	0.85	.0000	.0088	.0058	.0030	.104	.0000	.0000	.1738	0.8
10909	Aug.28	V. slight.	V. slight.	0.02	2.10	0.90	.0000	.0064	.0044	.0020	.104	.0000	.0000	.1817	0.8
10910	Aug.28	Slight.	Slight, white.	0.02	2.35	1.00	.0000	.0098	.0048	.0050	.108	.0000	.0000	.1935	0.8
10911	Aug.28	Slight.	Slight, white.	0.02	2.35	1.35	.0000	.0116	.0058	.0058	.106	.0000	.0000	.1856	0.8
10912	Aug.28	Distinct.	Slight, white.	0.03	2.05	1.10	.0000	.0078	.0062	.0016	.104	.0020	.0000	.1935	0.8

Odor, none.—— The samples were collected in the order of their numbers, at the following depths, in feet, beneath the surface: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 and 110.

Microscopical Examination of Water from Lake Winnipiseogee, Lakeport, New Hampshire, at Various Depths.

[Number of organisms per cubic centimeter.]

	1893.											
	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.
Day of examination, . .	30	30	30	30	30	30	30	30	30	30	30	30
Number of sample, . .	10901	10902	10903	10904	10905	10906	10907	10908	10909	10910	10911	10912
PLANTS.												
Diatomaceæ, . .	**58**	**107**	**107**	**69**	**76**	**54**	**46**	**71**	**30**	**49**	**76**	**38**
Asterionella, . .	3	17	12	14	18	4	2	16	3	5	0	3
Cyclotella, . . .	1	4	4	10	4	10	2	10	3	2	5	2
Fragilaria, . . .	0	19	0	0	20	7	15	1	0	0	7	0
Melosira, . . .	5	10	1	2	0	0	0	16	5	16	14	13
Stephanodiscus, . .	3	1	2	pr.	2	0	0	0	0	0	0	0
Synedra, . . .	4	12	16	1	4	1	1	2	pr.	0	0	0
Tabellaria, . . .	42	44	72	42	28	32	26	26	19	26	50	20
Cyanophyceæ, . .	**134**	**7**	**3**	**1**	**0**	**1**	**1**	**2**	**pr.**	**1**	**pr.**	**1**
Cœlosphærium, . .	2	3	2	pr.	0	pr.	0	0	0	0	0	0
Microcystis, . . .	pr.	0	0	0	0	1	1	1	pr.	pr.	pr.	0
Nostoc, . . .	12	4	1	1	0	0	0	1	0	1	0	1
Rivularia, . . .	120	0	0	0	0	0	0	0	0	0	0	0

LAKE WINNIPISEOGEE.

Microscopical Examination of Water from Lake Winnipiseogee, Lakeport, New Hampshire, at Various Depths — Concluded.

[Number of organisms per cubic centimeter.]

	1893.											
	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.	Aug.
PLANTS — Con.												
Algæ, ...	3	2	4	9	2	0	1	2	0	3	2	0
Chlorococcus, . .	2	1	0	0	2	0	0	0	0	3	0	0
Glœocystis, . . .	1	pr.	2	6	0	0	0	1	0	0	0	0
Staurastrum, . .	0	1	2	3	0	0	1	1	0	pr.	2	0
Fungi, Molds, . .	4	2	1	0	pr.	0	8	0	pr.	0	0	0
ANIMALS.												
Rhizopoda, Difflugia, .	0	0	0	0	pr.	0	pr.	0	pr.	0	0	0
Infusoria, . . .	2	4	2	5	2	2	4	1	pr.	0	0	0
Dinobryon cases, .	0	3	1	2	2	2	3	0	0	0	0	0
Peridinium, . . .	2	1	1	3	pr.	0	1	1	pr.	0	0	0
Miscellaneous, Zoöglœa, .	3	2	4	pr.	6	pr.	16	3	18	3	14	14
TOTAL, ...	204	124	121	84	86	57	76	79	48	56	92	53

MILLER'S RIVER.

Chemical Examination of Water from Miller's River at Athol and Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13176	Oct. 20	V. slight.	Cons.	0.90	4.05	2.10	.0004	.0194	.0176	.0018	.21	.0000	.0000	.8295	0.9
13175	Oct. 20	Slight.	Cons.	1.00	4.60	1.90	.0038	.0214	.0198	.0016	.23	.0050	.0000	.8571	0.9

Odor, faintly vegetable. —— The first sample was collected from the river at a highway bridge about a mile and a half below Athol and three miles above Orange; the last from the river just above the bridge in the village of Orange.

The samples were collected during an investigation of a complaint of a disagreeable odor from the river bed and banks in the village of Orange at times when the mill-pond was drawn down.

Microscopical Examination.

No. 13176. Diatomaceæ, *Navicula*, 1; *Synedra*, 10. Algæ, *Cosmarium*, 1. Fungi, *Crenothrix*, 116. Miscellaneous, *Zoöglœa*, 312. Total, 440.

No. 13175. Diatomaceæ, *Diatoma*, 1; *Melosira*, 3; *Synedra*, 2. Fungi, *Crenothrix*, 40. Infusoria, *Trachelomonas*, 1. Miscellaneous, *Zoöglœa*, 84. Total, 131.

NASHUA RIVER.

Regular monthly examinations of water from the North Branch of the Nashua River below Fitchburg have been continued as in the previous year. Weekly examinations of the North Branch just above its confluence with the South Branch at Lancaster were begun in July and continued until December.

NASHUA RIVER.

A large number of examinations of water from various brooks and ponds in the water-sheds of the Stillwater and Quinepoxet rivers, which unite at West Boylston to form the South Branch of the Nashua River, have been made during the past two years, and the results are given in the tables which follow, together with the results of the regular monthly examinations of the Quinepoxet and Stillwater rivers, and of the Nashua River above Clinton. These examinations were made in connection with the investigations for a metropolitan water supply for Boston and its suburbs.

Weekly examinations have been made of the water of the South Branch of the Nashua River just above its confluence with the North Branch at Lancaster corresponding to the examinations of the North Branch at this point.

Chemical Examination of Water from the North Branch of the Nashua River below Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11636	Jan. 15	Decided.	Cons., gray.	0.50	7.90	2.60	.0504	.0380	.0268	.0112	.67	.0200	.0008	.6396	1.9
11744	Feb. 12	Decided, milky.	Cons., gray.	0.38	6.20	1.80	.0592	.0198	.0140	.0058	.66	.0250	.0006	.5080	1.7
11874	Mar. 12	Slight.	Cons., gray.	0.45	3.00	0.95	.0048	.0180	.0126	.0054	.23	.0180	.0001	.4824	0.9
12051	Apr. 16	Distinct.	Cons., gray.	0.40	3.40	1.30	.0064	.0206	.0138	.0068	.30	.0120	.0003	.4440	0.8
12217	May 14	Slight.	Cons.	0.58	6.95	2.10	.0406	.0390	.0342	.0048	.70	.0150	.0011	.5444	1.8
12397	June 18	Distinct.	Heavy, gray.	0.75	9.50	2.10	.1440	.0678	.0332	.0346	1.11	.0070	.0015	.6568	2.6
12546	July 16	Distinct.	Cons., brown.	0.70	9.20	2.70	.1344	.0454	.0374	.0080	1.04	.0050	.0020	.6822	2.5
12769	Aug. 15	Slight.	Cons., brown.	0.75	10.65	1.65	.1650	.0410	.0342	.0068	1.22	.0080	.0040	.6737	2.5
12993	Sept. 19	V. slight, milky.	Cons.	0.65	9.05	2.40	.0464	.0268	.0236	.0032	.92	.0230	.0110	.5390	2.1
13146	Oct. 16	Distinct.	Cons., gray.	0.55	9.20	2.45	.0640	.0342	.0304	.0038	.97	.0100	.0014	.6517	2.5
13347	Nov. 20	Distinct.	Cons., gray.	0.55	7.50	2.00	.0384	.0396	.0260	.0136	.69	.0210	.0007	.6568	2.1
13517	Dec. 17	Decided.	Cons., gray.	0.45	6.10	1.90	.0076	.0250	.0156	.0094	.52	.0180	.0003	.5082	1.7
Av.	1894	....	....	0.56	7.39	2.00	.0634	.0346	.0251	.0095	.75	.0152	.0020	.5822	1.9
Av.	1893	....	....	0.57	7.46	2.16	.0461	.0360	.0257	.0103	.69	.0118	.0018	.6927	2.0

NOTE to analyses of 1894: Odor, musty and frequently disagreeable.—The samples were collected from the river about half a mile below the point where water from the tail-race of the Falulah Paper Company enters the stream.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 1,112, consisting chiefly of *Zoöglœa*.

NASHUA RIVER.

Chemical Examination of Water from the North Branch of the Nashua River, just above its Confluence with the South Branch at Lancaster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12593	July 23	Slight.	Cons., brown.	0.60	8.00	2.25	.0018	.0226	.0170	.0056	.94	.0290	.0018	.5513	2.1
12624	July 30	V. slight, milky.	Slight, yellow.	0.48	7.65	1.40	.0028	.0204	.0188	.0016	1.00	.0300	.0003	.4535	2.2
12665	Aug. 6	Slight.	Slight, brown.	0.45	8.40	2.00	.0142	.0228	.0198	.0030	1.08	.0300	.0013	.4096	2.3
12747	Aug. 14	Slight.	Cons., fibrous.	0.30	8.35	1.50	.0042	.0190	.0186	.0004	1.13	.0380	.0005	.4158	2.2
12787	Aug. 20	Slight.	Cons., brown.	0.40	8.95	2.35	.0064	.0256	.0204	.0052	.96	.0300	.0008	.4504	2.4
12843	Aug. 28	Slight.	Cons., brown.	0.30	4.65	1.15	.0134	.0216	.0158	.0058	.42	.0100	.0005	.2502	1.6
12890	Sept. 5	Slight.	Cons., brown.	0.30	4.05	1.00	.0136	.0210	.0148	.0062	1.14	.0400	.0011	.3850	2.2
12943	Sept. 12	Slight.	Cons., brown.	0.50	11.50	2.25	.0592	.0266	.0202	.0064	1.48	.0550	.0040	.4851	2.5
13007	Sept. 20	Slight.	Cons., reddish.	0.60	8.60	2.50	.0384	.0258	.0188	.0070	.98	.0350	.0036	.5005	2.1
13034	Sept. 26	V. slight.	Cons.	0.50	8.40	2.15	.0160	.0186	.0166	.0020	.96	.0380	.0020	.4404	2.1
13074	Oct. 3	Slight, milky.	Slight.	0.32	8.95	1.70	.0184	.0196	.0182	.0014	1.11	.0380	.0009	.4424	2.9
13122	Oct. 11	Distinct, clayey.	Cons., brown.	0.70	10.50	1.95	.0328	.0306	.0226	.0080	1.36	.0400	.0009	.6194	2.6
13163	Oct. 17	Slight, milky.	Slight.	0.50	8.65	2.80	.0232	.0204	.0180	.0024	1.04	.0200	.0004	.4716	2.6
13209	Oct. 24	Slight, milky.	Slight, gray.	0.60	10.25	2.60	.0608	.0248	.0204	.0044	1.34	.0180	.0005	.5100	2.9
13234	Oct. 31	Distinct, milky.	Slight, earthy.	0.65	9.65	2.05	.0576	.0216	.0180	.0036	1.23	.0130	.0005	.5043	2.6
13267	Nov. 6	Distinct, milky.	Cons., gray.	0.70	7.10	2.00	.0232	.0280	.0176	.0104	.40	.0250	.0004	.6083	2.2
13302	Nov. 13	Distinct.	Slight.	0.50	7.65	2.35	.0288	.0214	.0178	.0036	.78	.0250	.0003	.6802	2.2
13339	Nov. 20	Distinct.	Slight.	0.53	7.05	2.15	.0256	.0196	.0160	.0036	.70	.0220	.0005	.5889	1.9
13385	Nov. 27	Distinct, milky.	Cons., gray.	0.45	6.95	1.90	.0234	.0228	.0194	.0034	.70	.0200	.0002	.5781	1.9
13476	Dec. 12	Decided, milky.	Cons.	0.60	8.45	2.00	.0800	.0340	.0280	.0060	.99	.0250	.0004	.5128	2.5
Av.*	....	....	....	0.51	8.13	1.98	.0312	.0245	.0199	.0046	.98	.0287	.0010	.4955	2.3

Averages by Years.

-	1888†	-	-	0.56	7.47	1.82	.0118	.0287	.0261	.0026	.72	.0257	.0012	-	-
-	1890‡	-	-	0.38	6.77	2.12	.0117	.0326	.0274	.0052	.62	.0214	.0014	-	2.6
-	1891§	-	-	0.46	10.20	2.25	.0365	.0266	.0235	.0031	1.18	.0331	.0012	-	2.8
-	1892‖	-	-	0.48	9.75	2.10	.0422	.0274	.0237	.0037	1.11	.0450	.0010	-	3.0
-	1894¶	-	-	0.51	8.13	1.98	.0312	.0245	.0199	.0046	.98	.0287	.0010	.4955	2.3

* Where more than one sample was collected in a month the average analysis for that month has been used in making the average.

† Four samples on September 17.

‡ Five samples in July and August.

§ August and October.

‖ August, October and November.

¶ July to December.

NOTE to analyses of 1894: Odor, musty or mouldy and frequently disagreeable. —— The samples were collected from the river at the railroad bridge, a short distance above its mouth.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 236, consisting chiefly of *Zoöglœa*.

NASHUA RIVER.

Chemical Examination of Water from Various Sources within the Water-shed of the Stillwater River.

[Parts per 100,000.]

Number.	Source.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1893.					
10764	Outlet of East Waushacum Pond, Sterling.	Aug. 9	V. slight.	Slight, fibrous.	0.03	None.	None.
10765	Outlet of West Waushacum Pond, Sterling.	Aug. 9	V. slight.	V. slight.	0.10	None.	None.
10773	Stillwater River, below Rocky Brook, Sterling.	Aug. 10	Distinct.	Cons., fibrous.	0.45	Faintly vegetable.	Distinctly vegetable.
10774	Rocky Brook, one mile above Justice Brook, Sterling	Aug. 10	Slight.	Slight.	0.15	Faintly vegetable.	Distinctly vegetable.
10778	Justice Brook, just above junction with Keyes Brook at line between Princeton and Sterling.	Aug. 10	V. slight.	V. slight.	0.85	None.	None.
10775	Babcock Brook, above East Wachusett Brook, Princeton.	Aug. 10	Slight.	Cons.	0.15	Distinctly vegetable and grassy.	Dist'ly veg. and faintly mouldy.
10776	East Wachusett Brook, below Babcock Brook, Princeton.	Aug. 10	Slight.	Cons.	1.00	Faintly vegetable.	Faintly vegetable.
10777	Keyes Brook, in East Princeton village.	Aug. 10	Slight.	Slight.	1.00	None.	None.

Chemical Examination of Water from Various Sources within the Water-shed of the Stillwater River — Concluded.

[Parts per 100,000.]

Number.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Organisms per Cubic Centimeter.
10764	2.10	0.55	.0002	.0158	.0128	.0030	.15	.0000	.0000	.1643	0.5	112
10765	2.95	1.50	.0002	.0152	.0118	.0034	.18	.0030	.0001	.2449	0.9	199
10773	3.10	1.50	.0000	.0186	.0154	.0032	.10	.0000	.0000	.6067	0.4	303
10774	4.45	1.10	.0010	.0110	.0090	.0020	.23	.0000	.0000	.2591	0.6	251
10778	2.50	1.70	.0000	.0226	.0192	.0034	.10	.0030	.0001	.7197	0.2	13
10775	2.40	0.75	.0000	.0116	.0084	.0032	.17	.0000	.0000	.2488	0.2	278
10776	3.85	2.20	.0000	.0300	.0248	.0052	.12	.0030	.0001	.7623	0.4	257
10777	3.30	2.00	.0000	.0318	.0266	.0052	.07	.0000	.0000	.9243	0.6	51

The samples were collected during an investigation for a metropolitan water supply for Boston and its suburbs.

NASHUA RIVER.

Chemical Examination of Water from the Stillwater River in Sterling.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
11566	Dec. 30	None.	V. slight.	0.53	2.90	1.00	.0006	.0122	.0102	.0020	.18	.0020	.0000	.5288	0.8
	1894.														
11702	Feb. 1	V. slight.	V. slight.	0.40	3.10	1.25	.0004	.0070	.0054	.0016	.18	.0050	.0000	.4226	0.6
11835	Mar. 2	V. slight.	Slight.	0.48	3.00	1.00	.0000	.0088	.0068	.0020	.16	.0030	.0000	.4320	0.6
11966	Mar. 31	V. slight.	Slight.	0.40	2.25	0.90	.0000	.0094	.0082	.0012	.14	.0030	.0000	.3873	0.5
12152	May 2	V. slight.	Slight.	0.60	2.85	1.25	.0016	.0158	.0126	.0032	.15	.0000	.0000	.6120	0.3
12409	June 20	Slight.	Slight.	0.55	3.10	1.25	.0008	.0162	.0138	.0024	.12	.0000	.0000	.4620	0.6
12475	June 29	V. slight.	Slight.	0.50	2.90	0.85	.0026	.0166	.0152	.0014	.18	.0000	.0000	.5621	1.3
12663	Aug. 6	Slight.	Slight.	0.47	3.25	1.05	.0000	.0174	.0138	.0036	.16	.0000	.0000	.3711	1.3
12879	Sept. 4	Slight.	Slight.	0.33	4.05	1.40	.0008	.0146	.0128	.0018	.17	.0050	.0000	.3003	1.1
13084	Oct. 3	V. slight.	Cons.	0.25	3.40	1.15	.0004	.0150	.0134	.0016	.18	.0000	.0000	.3081	0.8
13254	Nov. 2	Slight.	Slight.	0.43	3.90	1.30	.0024	.0190	.0158	.0032	.29	.0000	.0000	.4404	0.8
13431	Dec. 4	V slight.	V. slight.	0.45	3.70	1.30	.0000	.0120	.0100	.0020	.20	.0030	.0000	.5043	1.3
Av.	....	....	....	0.45	3.20	1.14	.0008	.0137	.0115	.0022	.18	.0017	.0000	.4442	0.8

Averages by Years.

-	1892	-	-	0.44	3.38	1.18	.0001	.0131	.0109	.0022	.13	.0072	.0000	-	0.9
-	1893*	-	-	0.50	3.45	1.38	.0006	.0147	.0126	.0021	.18	.0022	.0001	.4931	0.7
-	1894	-	-	0.45	3.20	1.14	.0008	.0137	.0115	.0022	.18	.0017	.0000	.4442	0.8

* August to December.

NOTE to analyses of 1894: Odor, vegetable. —— The samples were collected from the river at a highway bridge about one mile above the line between Sterling and West Boylston.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 57.

NASHUA RIVER.

Chemical Examination of Water from Various Sources

[Parts per 100,000.]

	Number.	Source.	Date of Collection.	Appearance.			Odor.	
				Turbidity.	Sediment.	Color.	Cold.	Hot.
			1893.					
1	10791	Trout Brook, West Boylston.	Aug.14	V. slight.	V. slight.	0.95	Very faint or none.	Faintly vegetable.
2	10779	Chaffin's Pond, Holden.	Aug.11	V. slight.	Slight.	1.30	Distinctly vegetable.	Distinctly vegetable.
			1894.					
3	13188*	Chaffin's Pond, Holden.	Oct. 23	Slight.	Slight.	1.40	Distinctly vegetable and mouldy.	Distinctly veg'table and unpleasant.
			1893.					
4	10780	Dawson's Mill-pond, Holden.	Aug.11	V. slight.	Slight.	0.65	Faintly vegetable.	Faintly vegetable and mouldy.
			1894.					
5	13191	Pine Hill Reservoir, Holden.	Oct. 23	Distinct.	Cons., green.	0.30	Decidedly veg'table and unpleasant.	Decidedly veg'table and disagreeable.
6	13190*	Eagleville Reservoir, Holden.	Oct. 23	Distinct.	Cons., green.	0.43	Distinctly vegetable.	Distinctly veg'table and grassy.
			1893.					
7	10782	Asnebumskit Brook below Eagleville Reservoir, Holden.	Aug.11	Slight.	Cons., floc.	0.70	Faintly vegetable.	Distinctly vegetable.
8	10792	Asnebumskit Brook below mills at Jeffersonville in Holden.	Aug.15	-	-	0.85	-	-
9	10787	Millpond at Ruralville, on Quinepoxet River, Holden	Aug.11	Slight.	Slight, fibrous.	0.50	Faintly vegetable.	Distinctly vegetable.
			1894.					
10	13189*	Stream below Kendall Reservoir, Holden.	Oct. 23	V. slight.	Slight.	0.50	Distinctly vegetable.	Distinctly veg'table and sweetish.
			1893.					
11	10781	Lower Asnebumskit Pond, Paxton.	Aug.11	V. slight.	Slight.	0.90	Faintly vegetable.	Distinctly vegetable and mouldy.
12	10788	Muschopaugue Pond, Rutland.	Aug.11	Slight.	Cons., earthy.	0.25	None.	None.

* Samples marked with an asterisk were collected while making an examination of possible sources metropolitan water supply for Boston and its suburbs.

within the Water-shed of the Quinepoxet River.

[Parts per 100,000.]

Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Organisms per Cubic Centimeter.	
			Albuminoid.									
Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.				
4.55	1.90	.0004	.0192	.0164	.0028	.20	.0000	.0001	.7623	0.5	36	1
4.25	2.00	.0000	.0324	.0274	.0050	.26	.0000	.0001	1.0349	0.4	130	2
6.90	2.70	.0010	.0456	.0430	.0026	.33	.0030	.0001	1.2719	0.5	93	3
2.55	1.65	.0010	.0228	.0192	.0036	.14	.0000	.0000	.6952	0.2	124	4
4.75	1.75	.0004	.0260	.0190	.0070	.27	.0050	.0002	.5056	1.6	2,142	5
3.00	1.25	.0002	.0238	.0186	.0052	.21	.0030	.0000	.5633	0.8	906	6
3.00	1.60	.0000	.0290	.0228	.0062	.16	.0000	.0000	.6383	1.1	1,354	7
-	-	-	-	-	-	.16	-	-	-	-	-	8
3.05	1.65	.0046	.0250	.0190	.0060	.12	.0000	.0000	.5253	0.5	536	9
3.45	1.30	.0002	.0114	.0096	.0018	.17	.0000	.0000	.4068	0.8	47	10
2.90	1.70	.0000	.0308	.0206	.0102	.12	.0000	.0000	.6794	0.2	52	11
3.90	1.45	.0016	.0060	.0044	.0016	.11	.0000	.0000	.2212	0.5	1,040	12

of water supply for the city of Worcester, and the remaining samples during an investigation for a

NASHUA RIVER.

Chemical Examination of Water from the Quinepoxet River in Holden.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
11567	Dec. 30	V. slight.	Slight.	0.70	3.30	1.10	.0004	.0164	.0140	.0024	.22	.0060	.0000	.6809	0.5
	1894.														
11701	Feb. 1	Distinct, clayey.	Slight.	0.53	3.05	1.25	.0012	.0106	.0084	.0022	.21	.0070	.0000	.5293	0.9
11834	Mar. 2	Distinct.	Cons.	0.58	3.40	1.65	.0004	.0166	.0110	.0056	.21	.0050	.0000	.6024	0.6
11965	Mar. 31	Slight.	Cons.	0.55	2.60	1.15	.0000	.0150	.0100	.0050	.19	.0030	.0000	.4658	0.5
12151	May 2	Slight.	Cons.	0.70	3.15	1.65	.0000	.0200	.0172	.0028	.22	.0000	.0001	.7280	0.3
12410	June 20	Slight.	Slight.	0.70	3.45	1.55	.0030	.0232	.0202	.0030	.22	.0000	.0000	.6391	0.6
12476	June 29	Slight.	Slight.	0.70	4.10	1.50	.0250	.0246	.0176	.0070	.31	.0000	.0001	.5844	0.6
12662	Aug. 6	Distinct.	Cons., brown.	0.53	3.60	1.50	.0054	.0204	.0168	.0036	.24	.0000	.0001	.4836	1.6
12878	Sept. 4	Slight.	Cons., dark.	0.55	4.65	1.45	.0034	.0366	.0310	.0056	.40	.0020	.0003	.4389	0.9
13083	Oct. 3	Slight.	Cons.	0.43	4.45	1.50	.0070	.0200	.0164	.0036	.37	.0030	.0001	.4147	0.6
13253	Nov. 2	Distinct, clayey.	Slight, gray.	0.65	5.40	1.95	.0036	.0352	.0264	.0088	.55	.0000	.0002	.7454	0.5
13432	Dec. 4	Distinct.	Cons.	0.65	5.00	1.45	.0004	.0184	.0162	.0022	.31	.0070	.0001	.6838	1.4
Av.	....	....	....	0.61	3.85	1.47	.0041	.0214	.0171	.0043	.29	.0027	.0001	.5830	0.7

Averages by Years.

-	1892	-	-	0.62	3.70	1.49	.0014	.0194	.0158	.0036	.19	.0088	.0001	-	0.9
-	1893*	-	-	0.72	3.75	1.57	.0004	.0192	.0160	.0032	.26	.0044	.0001	.6477	0.9
-	1894	-	-	0.61	3.85	1.47	.0041	.0214	.0171	.0043	.29	.0027	.0001	.5830	0.7

* August to December.

Note to analyses of 1894: Odor, vegetable, sometimes none. —— The samples were collected from the river at Smith's Woollen Mill in Holden, and one thousand feet from the line between Holden and West Boylston.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 261. The lowest number was 5 and the highest 736, consisting chiefly of *Zoöglœa*.

NASHUA RIVER.

Chemical Examination of Water from the South Branch of the Nashua River above Clinton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11592	Jan. 2	Slight.	Slight.	0.55	4.10	1.35	.0012	.0132	.0106	.0026	.22	.0090	.0000	.5499	0.9
11700	Feb. 1	Slight, clayey.	Slight.	0.33	3.55	1.20	.0016	.0120	.0094	.0026	.27	.0050	.0000	.4029	1.3
11819	Mar. 1	Distinct, clayey.	Cons., fibrous.	0.50	3.75	1.20	.0028	.0190	.0144	.0046	.27	.0070	.0000	.5080	0.6
11983	Apr. 2	Slight.	Slight.	0.45	3.20	1.35	.0000	.0130	.0110	.0020	.19	.0030	.0000	.4335	0.6
12157	May 4	Slight.	Slight.	0.60	3.35	1.30	.0006	.0126	.0092	.0034	.17	.0050	.0000	.5440	0.9
12294	June 1	Slight.	Cons.	0.85	3.40	1.00	.0046	.0218	.0164	.0054	.17	.0030	.0000	.6622	0.8
12484	July 6	Slight.	Slight.	0.45	3.40	1.25	.0008	.0158	.0126	.0032	.23	.0030	.0000	.3634	0.9
12664	Aug. 6	Distinct.	Slight.	0.47	3.50	1.00	.0000	.0192	.0162	.0030	.28	.0000	.0000	.3319	1.0
12880	Sept. 4	Slight.	Slight.	0.30	4.50	1.50	.0014	.0138	.0110	.0028	.29	.0030	.0000	.2079	1.3
13081	Oct. 3	Slight.	Slight.	0.15	3.85	1.30	.0018	.0120	.0092	.0028	.16	.0020	.0000	.2409	1.8
13250	Nov. 1	V. slight.	Slight.	0.20	4.25	1.35	.0014	.0120	.0090	.0030	.39	.0030	.0000	.2733	1.6
13429	Dec. 3	Slight.	V. slight.	0.48	4.85	1.45	.0006	.0210	.0192	.0018	.33	.0070	.0001	.4913	1.7
Av.	....	....	....	0.44	3.81	1.27	.0014	.0154	.0123	.0031	.25	.0042	.0000	.4174	1.1

Averages by Years.

-	1887*	-	-	0.58	4.14	1.24	.0015	.0216	-	-	.21	.0077	-	-	-
-	1888	-	-	0.32	3.53	1.06	.0008	.0151	-	-	.18	.0097	.0001	-	-
-	1889†	-	-	0.24	2.96	0.87	.0004	.0163	.0133	.0030	.18	.0062	.0002	-	-
-	1893‡	-	-	0.41	3.99	1.42	.0006	.0158	.0129	.0029	.28	.0020	.0001	.4623	1.4
-	1894	-	-	0.44	3.81	1.27	.0014	.0154	.0123	.0031	.25	.0042	.0000	.4174	1.1

* June to December. † January to May. ‡ August to December.

NOTE to analyses of 1894: Odor, vegetable, sometimes mouldy. —— The samples were collected from the river above the dam of the Lancaster Manufacturing Company.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 128.

NASHUA RIVER.

Chemical Examination of Water from the South Branch of the Nashua River, just above its Confluence with the North Branch at Lancaster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1894.														
12592	July 23	Decided, milky.	Cons., dark.	0.60	6.75	2.30	.0960	.0300	.0250	.0050	.62	.0150	.0040	.5351	1.7
12625	July 30	V. slight, milky.	Slight, yellow.	0.50	5.00	1.80	.0880	.0236	.0220	.0016	.58	.0080	.0022	.3927	1.9
12652	Aug. 1	Distinct.	Cons., brown.	0.35	5.05	1.50	.0200	.0236	.0180	.0056	.46	.0050	.0015	.4220	2.0
12666	Aug. 6	Slight.	Cons., brown.	0.48	4.90	1.45	.0384	.0236	.0190	.0046	.42	.0050	.0020	.3611	1.4
12746	Aug. 14	Slight.	Cons., fibrous.	0.40	5.65	1.05	.0174	.0274	.0212	.0062	.40	.0130	.0007	.4658	1.1
12788	Aug. 20	Slight.	Cons., brown.	0.50	6.20	2.10	.0560	.0164	.0094	.0070	.53	.0150	.0013	.2887	1.7
12842	Aug. 28	Slight.	Cons., brown.	0.40	8.80	2.25	.0052	.0226	.0194	.0032	1.12	.0480	.0012	.4312	2.5
12889	Sept. 5	Distinct.	Slight, fibrous.	0.45	7.65	1.95	.1440	.0296	.0224	.0072	.74	.0080	.0020	.3696	1.9
12942	Sept. 12	Slight.	Slight, fibrous.	0.45	6.30	2.60	.1040	.0710	.0640	.0070	.44	.0080	.0012	.3773	1.8
13006	Sept. 20	Distinct.	Cons., rusty.	0.90	8.95	2.40	.1600	.0450	.0340	.0110	.72	.0020	.0007	.6391	1.6
13033	Sept. 26	Slight.	Slight.	0.40	6.35	2.00	.0440	.0290	.0180	.0110	.56	.0070	.0030	.4196	1.8
13073	Oct. 3	Slight, milky.	Slight.	0.40	6.75	2.15	.0480	.0290	.0190	.0100	.64	.0040	.0065	.4661	1.9
13121	Oct. 11	Distinct, clayey.	Slight, gray.	0.50	7.25	2.00	.0368	.0316	.0276	.0040	.66	.0070	.0028	.5434	1.9
13162	Oct. 17	Distinct, milky.	Slight.	0.40	6.50	2.25	.0416	.0252	.0220	.0032	.62	.0060	.0040	.4858	1.9
13208	Oct. 24	Slight, milky.	Cons., brown.	0.50	7.15	2.45	.0448	.0348	.0244	.0104	.63	.0030	.0015	.5253	1.8
13233	Oct. 31	Distinct, milky.	Cons., earthy.	0.42	8.25	2.10	.0400	.0316	.0264	.0052	.87	.0050	.0013	.5890	2.2
13266	Nov. 6	Distinct, milky.	Cons., gray.	0.40	5.60	1.55	.0200	.0354	.0154	.0200	.53	.0100	.0006	.4350	1.9
13301	Nov. 13	Distinct.	Cons., green.	0.75	5.45	1.65	.0512	.0216	.0172	.0044	.18	.0090	.0004	.4586	1.7
13338	Nov. 20	Distinct.	Cons.	0.53	6.20	1.75	.0168	.0244	.0188	.0056	.51	.0150	.0006	.5655	1.9
13384	Nov. 27	Slight.	Slight.	0.63	5.40	1.65	.0264	.0184	.0154	.0030	.36	.0150	.0003	.5371	1.8
13475	Dec. 12	Distinct.	Slight.	0.55	5.75	1.65	.0160	.0228	.0196	.0032	.54	.0050	.0003	.5251	1.8
Av.*	....	....	....	0.52	6.31	1.91	.0532	.0285	.0226	.0076	.57	.0095	.0017	.4758	1.8

Averages by Years.

–	1888†	–	–	0.20	4.91	1.11	.0264	.0230	.0173	.0047	.38	.0192	.0008	–	–
–	1890‡	–	–	0.30	4.68	1.85	.0162	.0288	.0213	.0075	.31	.0104	.0003	–	1.7
–	1891§	–	–	0.45	6.01	2.22	.0141	.0338	.0242	.0096	.39	.0093	.0003	–	1.6
–	1892‖	–	–	0.43	5.68	1.65	.0181	.0267	.0214	.0053	.59	.0150	.0006	–	1.8
–	1894¶	–	–	0.52	6.31	1.91	.0532	.0285	.0226	.0076	.57	.0095	.0017	.4758	1.8

* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.
† Four samples on September 17.
‡ Four samples in July and August.
§ August and October.
‖ August, October and November.
¶ July to December.

NOTE to analyses of 1894: Odor, musty and frequently disagreeable. — The samples were collected from the river at the Atherton bridge, a short distance above its mouth.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 414.

Shawsheen River.

Chemical Examination of Water from the Shawsheen River at Wilmington.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12285	May 25	V. slight.	Slight.	1.60	5.60	2.55	.0006	.0232	.0224	.0008	.30	.0070	.0000	.7738	1.6
12323	June 6	V. slight.	Slight.	1.80	5.90	2.80	.0004	.0390	.0356	.0034	.29	.0030	.0000	1.6170	1.4
12470	July 5	V. slight.	Cons.	0.50	4.35	1.40	.0026	.0174	.0150	.0024	.36	.0000	.0000	.4420	1.6
12667	Aug. 6	V. slight.	V. slight.	0.50	4.45	1.25	.0008	.0158	.0144	.0014	.41	.0000	.0001	.4350	1.5
12892	Sept. 5	V. slight.	Slight.	0.15	7.35	2.70	.0006	.0096	.0078	.0018	.36	.0000	.0001	.2002	1.7
13072	Oct. 2	V. slight.	Slight.	0.15	4.65	0.90	.0000	.0092	.0080	.0012	.42	.0020	.0000	.2251	1.7
13255	Nov. 5	V. slight.	Slight.	0.83	7.15	2.50	.0006	.0246	.0214	.0032	.48	.0000	.0000	.8431	2.2
13445	Dec. 5	V. slight.	V. slight.	0.65	7.10	2.70	.0006	.0198	.0186	.0012	.50	.0150	.0002	.8123	2.2
Av.	....	....	....	0.77	5.82	2.10	.0005	.0198	.0179	.0019	.39	.0034	.0001	.6686	1.7

Odor, generally vegetable. —— The samples were collected from the river at the point where it is crossed by the old Middlesex Canal, between Wilmington and Billerica, during an investigation for a metropolitan water supply for Boston and its suburbs.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 46.

Chemical Examination of Water from Lubber Brook, Wilmington.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
13157	Oct. 17	Slight.	Slight, yellow.	2.10	–	–	.0012	.0398	–	–	.50	.0050	.0000	–	2.5

Odor, very faintly vegetable. —— The sample was collected from the brook at a highway crossing near Silver Lake station on the southern division of the Boston and Maine Railroad.

STONY BROOK.

STONY BROOK.

Chemical Examination of Water from Stony Brook, Boston.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12620	July 27	Decided, yellow.	Cons., rusty.	1.20	23.50	6.00	.0336	.0368	.0314	.0054	3.10	.1000	.0170	.8046	9.2
12621	July 27	Decided, milky.	Cons., dark.	0.60	474.00	81.00	.2640	.0890	.0480	.0410	225.00	.0200	.0120	1.1165	83.0
12950	Sept.17	Decided.	Cons.	0.65	19.10	5.10	.1640	.0270	.0190	.0080	2.80	.2000	.0080	.3927	8.0

Odor of the first sample decidedly musty; of the second, decidedly musty and offensive; of the third, offensive. —— The first and last samples were collected just above the gate-house at Roxbury and the second sample from the gate-house at Huntington Avenue.

Microscopical Examination.

Nos. 12620 and 12621 not examined.

No 12960 contained 351 organisms per cubic centimeter, most of which were *Zoöglœa*.

SWIFT RIVER.

Chemical Examination of Water from the East Branch of the Swift River at Greenwich.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12106	Apr. 25	V. slight.	Cons.	0.58	2.55	1.20	.0022	.0172	.0136	.0036	.14	.0000	.0000	.5648	0.3
13226	Oct. 30	V. slight.	Slight.	0.35	3.65	1.00	.0000	.0120	.0098	.0022	.15	.0030	.0000	.3773	1.3

Odor, faintly vegetable. —— The samples were collected from the east branch of the Swift River, just above its confluence with the middle branch, during an investigation for a metropolitan water supply for Boston and its suburbs.

Microscopical Examination.

No. 12106. Total number of organisms per cubic centimeter, 16.

No. 13226. Total number of organisms per cubic centimeter, 8.

SWIFT RIVER.

Chemical Examination of Water from the Middle Branch of the Swift River at Greenwich.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12105	Apr. 25	V. slight.	Slight.	0.43	2.65	1.10	.0024	.0124	.0106	.0018	.14	.0000	.0000	.4424	0.5
13227	Oct. 30	Slight.	Slight.	0.32	3.65	0.95	.0000	.0106	.0088	.0018	.11	.0000	.0000	.3349	1.3

Odor, faintly vegetable. —— The samples were collected from the middle branch of the Swift River, just above its confluence with the east branch, during an investigation for a metropolitan water supply for Boston and its suburbs.

Microscopical Examination.

No. 12105. Total number of organisms per cubic centimeter, 108.
No. 13227. Total number of organisms per cubic centimeter, 44.

Chemical Examination of Water from the West Branch of the Swift River at Enfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12104	Apr. 25	V. slight.	Slight.	0.20	1.85	0.70	.0026	.0108	.0100	.0008	.16	.0000	.0000	.3065	0.2
13516	Dec. 13	Slight.	Heavy, gray.	0.23	3.10	1.05	.0008	.0108	.0064	.0044	.12	.0070	.0000	.2772	0.8
13549	Dec. 26	None.	Slight.	0.10	2.75	0.80	.0000	.0094	.0076	.0018	.12	.0030	.0000	.2502	0.9
Av.	....	....	....	0.18	2.57	0.85	.0011	.0103	.0080	.0023	.13	.0033	.0000	.2780	0.6

Odor, very faintly vegetable. —— The samples were collected from the west branch of the Swift River at a road crossing about half a mile above its confluence with the main stream, during an investigation for a metropolitan water supply for Boston and its suburbs.

Microscopical Examination.

No. 12104. Total number of organisms per cubic centimeter, 12.
No. 13516. Total number of organisms per cubic centimeter, 294.
No. 13549. Total number of organisms per cubic centimeter, 14.

Ten Mile River.

Chemical Examination of Water from the Ten Mile River, at Attleborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
12532	July 16	Distinct.	Slight, rusty.	0.50	4.15	1.15	.0016	.0174	.0146	.0028	.42	.0000	.0003	.3118	1.7
12531	July 16	Slight.	Slight.	0.50	5.55	1.75	.0118	.0276	.0202	.0074	.78	.0200	.0006	.3688	1.7

Odor, of the first sample, distinctly vegetable and mouldy and faintly disagreeable; of the second, decidedly disagreeable, becoming decidedly vegetable and musty on heating. —— The first sample was collected from the Ten Mile River, about 200 feet below the mouth of the Bungay River; at the time the sample was collected the water in the Ten Mile River came almost wholly from the Bungay River. The second sample was collected from the Ten Mile River about 500 feet below the railroad bridge on the main line of the Boston & Providence Railroad.

Microscopical Examination.

No. 12532. Diatomaceæ, *Cyclotella*, 4; *Pinnularia*, 1; *Synedra*, 36; *Tabellaria*, 2. Algæ, *Protococcus*, 15. Fungi, *Crenothrix*, 248. Total, 306.

No. 12531. Diatomaceæ, *Melosira*, 2; *Navicula*, 2; *Pinnularia*, 1; *Synedra*, 104; *Tabellaria*, 2. Algæ, *Chlorococcus*, 10; *Closterium*, 1; *Protococcus*, 10; *Raphidium*, 88; *Scenedesmus*, 20; *Sorastrum*, 7; *Staurogenia*, 4. Fungi, *Crenothrix*, 1 Infusoria, *Monas*, 3; *Peridinium*, 1; *Phacus*, 1; *Trachelomonas*, 1. Miscellaneous, *Zoöglœa*, 20. Total, 278.

Ware River.

Chemical Examination of Water from Ware River at Cold Brook Station, Barre.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1894.														
11569	Jan. 1	Slight.	Slight.	0.73	3.90	1.55	.0004	.0166	.0148	.0018	.17	.0030	.0000	.7215	0.6
11699	Feb. 1	Slight.	Slight.	0.60	3.50	1.50	.0016	.0116	.0096	.0020	.18	.0070	.0000	.5783	0.8
11820	Mar. 1	V. slight.	Slight.	0.75	3.55	1.25	.0006	.0166	.0122	.0044	.14	.0030	.0000	.6760	0.8
11984	Apr. 2	V. slight.	Slight.	0.70	2.90	1.30	.0004	.0132	.0112	.0020	.13	.0030	.0000	.5505	0.2
12128	May 1	Slight.	Slight.	0.95	2.90	1.75	.0000	.0184	.0168	.0016	.13	.0000	.0000	.8520	0.2
12324	June 6	Slight.	Slight.	1.30	3.70	1.70	.0010	.0246	.0226	.0020	.08	.0050	.0000	.9471	0.3
12471	July 5	V. slight.	Slight.	0.85	3.60	1.45	.0008	.0190	.0172	.0018	.10	.0000	.0000	.5644	0.8
12658	Aug. [illegible]	Slight.	Slight, rusty.	0.70	3.35	1.50	.0000	.0178	.0164	.0014	.10	.0000	.0000	.5082	1.4
12857	Sept. 4	Slight.	Slight.	0.63	3.25	1.25	.0006	.0222	.0164	.0058	.14	.0000	.0001	.4004	0.9
13104	Oct. 9	Slight.	Slight.	0.45	3.15	1.05	.0000	.0170	.0152	.0018	.15	.0000	.0000	.4180	0.6
13235	Nov. 1	Slight.	Slight.	0.50	3.50	1.40	.0004	.0174	.0150	.0024	.13	.0000	.0000	.4759	1.1
13407	Dec. 3	V. slight.	V. slight.	0.70	5.35	2.00	.0008	.0206	.0184	.0022	.21	.0070	.0000	.8393	1.4
Av.	....	....	....	0.74	3.55	1.47	.0005	.0179	.0155	.0024	.14	.0023	.0000	.6276	0.8

Odor, generally distinctly vegetable, rarely mouldy or unpleasant. —— The samples were collected from the river, at the railroad bridge near Cold Brook station, in the southeasterly part of the town of Barre.

Microscopical Examination.

The average number of organisms per cubic centimeter found in these samples was 126.

WARE RIVER.

Chemical Examination of Water from Various Sources within the Water-shed of the Ware River.

[Parts per 100,000.]

Number.	Source.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.
		1893.			
10785	Asnecomick Pond at outlet, Hubbardston.	Aug.12	Slight.	Slight, threads.	0.02
10931	East Branch of Ware River above the village of New Boston, Rutland.	Aug.30	Distinct, green.	Slight, brown.	1.00
10916	Long Pond, Rutland.	Aug.30	V. slight.	Slight, brown.	0.30
10932	Long Meadow Brook just above Ware River, Rutland.	Aug.30	Slight.	Slight, fibrous.	1.10
10940	East Branch Ware River above Barre Falls, Barre.	Aug.31	Slight, brown.	Slight.	0.95
10938	West Branch Ware River above Barre Falls, Barre.	Aug.31	V. slight.	Slight.	1.20
10939	Ware River below junction of East and West Branches, Barre.	Aug 31	Slight.	Slight	1.15
10780	Ware River just above the village of Smithville, Barre.	Aug.12	Slight.	Cons., white.	0.50
10937	Burnshirt River above Canesto Brook, Barre.	Aug.31	V. slight.	V. slight.	0.75
10936	Canesto Brook above Burnshirt River, Barre.	Aug.31	Slight, green.	Slight, brown.	0.90
10918	Muddy Pond, Oakham.	Aug.30	Slight.	Slight.	0.70
10917	Sulphur and iron springs at Cold Brook, Oakham.*	Aug.30	Decided, iron oxide.	Heavy, iron oxide.	0.18

Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Organisms per Cubic Centimeter.
1.55	0.45	.0000	.0102	.0086	.0016	.12	.0000	.0001	.1777	0.0	140
3.60	2.15	.0000	.0348	.0282	.0066	.12	.0000	.0000	.9006	0.5	247
2.85	1.80	.0012	.0206	.0178	.0028	.15	.0000	.0000	.4819	0.3	138
5.00	2.25	.0004	.0254	.0234	.0020	.19	.0000	.0000	.9124	1.1	125
3.85	1.60	.0000	.0286	.0250	.0036	.14	.0000	.0000	.8611	0.6	195
4.70	2.00	.0000	.0278	.0258	.0020	.12	.0000	.0000	1.0230	0.6	495
4.15	2.05	.0004	.0274	.0254	.0020	.13	.0000	.0000	1.0190	0.6	165
3.50	1.35	.0008	.0170	.0146	.0024	.14	.0000	.0000	.4266	0.6	274
4.20	1.60	.0000	.0178	.0156	.0022	.13	.0000	.0000	.7623	0.6	28
3.35	1.70	.0000	.0214	.0176	.0038	.11	.0000	.0000	.6241	0.5	239
3.50	1.20	.0004	.0104	.0084	.0020	.15	.0000	.0000	.3555	0.8	132
5.50	-	.0228	.0134	.0102	.0032	.14	.0020	.0001	.1264	0.9	2,563

* Iron in this sample, unfiltered, .2200; filtered, .1800.

Odor, of the first sample, none; of the last, peculiar, becoming very faintly earthy on heating; of the others, vegetable and sweetish. —— The samples were collected during an investigation for a metropolitan water supply for Boston and its suburbs.

SUMMARY

OF

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

SUMMARY OF WATER SUPPLY STATISTICS.

At the end of 1894 the State contained 31 cities and 322 towns, an increase of one in the number of cities, while the number of towns remains the same as in the previous year. The town of Beverly became a city March 23, 1894; and on June 1, 1894, a part of Longmeadow was set off and incorporated as the town of East Longmeadow.

A public water supply was introduced during this year for the first time into the towns of Fairhaven and Ipswich and into the portion of Wareham known as Onset, increasing the total number of places supplied in the State to 149.

In addition to new supplies in the places above mentioned, new works have been constructed in the town of Methuen, a limited portion of which was formerly supplied from a neighboring municipality, and in many other places additional works of less importance have been constructed to increase the capacity of existing sources of supply.

The following table gives the classification by population of cities and towns having and not having public water supplies Dec. 31, 1894. The populations are taken from the census of 1890: —

POPULATION (1890).	Number of Places of Given Population having a Public Water Supply.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	0	0	28	9,772
500-1,000,	5	4,566	64	48,740
1,000-1,500,	6	7,249	43	52,810
1,500-2,000,	8	13,857	28	49,992
2,000-2,500,	9	19,987	13	28,116
2,500-3,000,	8	22,582	17	46,343
3,000-3,500,	9	29,461	4	12,448
3,500-4,000,	7	26,328	2	7,392
4,000-4,500,	12	51,640	4	16,928
Above 4,500,	85	1,784,594	1	6,138
TOTALS,	149	1,960,264	204	278,679

From the totals given in the table it will be seen that, although but forty-two per cent. of the cities and towns in the State have a public water supply, yet the total population of places supplied represents 87.6 per cent. of the whole population of the State. In this estimate of the total population of municipalities supplied all of the inhabitants in them are included, and it consequently includes rather more than the actual number of persons to whom a public water supply is available; the difference, however, is not large.

There are now but 7 towns having, by the census of 1890, a population exceeding 3,500, which are not provided with a public water supply. These are given in the following table: —

Towns.	Population in 1890.	Towns.	Population in 1890.
Blackstone,	6,138	Barnstable,	4,023
Millbury,*	4,428	North Andover,	3,742
Winchendon,	4,390	Monson,*	3,650
Rockport,*	4,087		

* Works for the supply of the towns of Millbury, Rockport and Monson were nearly completed at the end of 1894.

In the following table the various water supplies are classified according to the dates when a fairly complete system of supply was first introduced into a city or town: —

Years.	Number of Places Supplied.	Years.	Number of Places Supplied.
Previous to 1850,	6	1891,	5
1850-1859, inclusive,	4	1892,	1
1860-1869, inclusive,	10	1893,	3
1870-1879, inclusive,	44	1894,	3
1880-1889, inclusive,	68		
1890,	5	Total,	149

Of the 31 cities in the Commonwealth, 29, having a total population in 1890 of 1,366,670, own their water works; while 2, having a total population of 38,598, are wholly supplied by private companies. Of the 118 towns having public water supplies, 70, with a total population of 356,079, are supplied from their own works, while 48, with a total population of 198,917, are supplied by private companies. The total population in both cities and towns owning their works is 1,722,749, against 237,515 in those supplied by private companies.

The following table gives statistics with regard to the consumption of water in many of the cities and towns in this State. The daily consumption per *inhabitant*, obtained by dividing the average daily consumption by the total population of the city or town, in 1894, is less than the amount per *consumer*, because there are some in all cities and towns who do not use the public water supply. This difference between the number of inhabitants and consumers accounts to a large extent for the low rate, per inhabitant, in some towns where works have been in operation only a short time, and in consequence water has not been generally introduced; also, in towns where there are villages to which the public water supply has not been extended; but, after making all due allowance for the varying proportion of water takers, there is still a very great difference in the amount of water used per person in different places, which it is very difficult to account for.

Statistics relating to the Consumption of Water in various Cities and Towns.

City or Town.	Population. 1894.	Average Daily Consumption. Gallons. 1894.	Daily Consumption per Inhabitant. Gallons.
Abington and Rockland,	9,669	365,000	38
Andover,	6,147	323,000	53
Attleborough,	8,145	272,000	33
Avon,	1,578	60,000	38
Ayer,	2,110	71,000	34
Beverly,	11,606	884,000	76
Boston (Cochituate Works),	445,517	46,576,000	105
Boston, Somerville, Chelsea and Everett (Mystic Works),	137,021	10,282,000	75
Braintree,	5,218	324,000	62
Bridgewater and East Bridgewater,	7,497	167,000	22
Brockton,	31,984	863,000	27
Brookline,	15,348	1,319,000	86
Cambridge,	79,221	5,830,000	74
Canton,	4,618	181,000	39
Cohasset,	2,471	67,000	27
Cottage City,	1,046	83,000	79
Danvers and Middleton,	8,891	585,000	66
Dedham,	7,199	368,000	51
Easton,	4,458	88,000	20
Fairhaven,*	3,254	41,000	13
Fall River,	85,296	2,438,000	29
Foxborough,	3,164	126,000	40
Framingham,	9,446	321,000	34
Franklin,	5,073	158,000	31
Gardner,	9,031	568,000	63
Gloucester,	27,061	773,000	29
Hyde Park,	11,501	458,000	40
Lawrence,	50,653	2,877,000	57
Lowell,	83,026	6,568,000	79
Lynn and Saugus,	65,367	4,020,000	62
Malden,	28,371	1,492,000	53

City or Town.	Population. 1894.	Average Daily Consumption. Gallons. 1894.	Daily Consumption per Inhabitant. Gallons.
Manchester,	1,859	115,000	62
Mansfield,	3,664	214,000	58
Marblehead,	7,772	217,000	28
Marlborough,	14,745	459,000	31
Medford,	13,800	699,000	51
Melrose,	11,277	681,000	60
Middleborough,	6,567	214,000	33
Milton,	5,270	129,000	25
Montague,	6,102	350,000	57
Nantucket,	3,067	81,000	26
Natick,	8,951	341,000	38
Needham,	3,416	112,000	33
New Bedford,	52,350	4,787,000	91
Newburyport,	14,433	621,000	43
Newton,	26,973	1,623,000	60
No. Attleborough,	6,606	184,000	28
North Brookfield,	4,482	84,000	19
Norwood,	4,406	220,000	50
Orange,	5,199	118,000	23
Peabody,	10,440	789,000	76
Quincy,	19,914	798,000	40
Randolph and Holbrook,	6,078	263,000	43
Reading,	4,586	224,000	49
Revere and Winthrop,	10,982	774,000	71
Salem,	33,710	2,303,000	68
Sharon,	1,700	39,000	23
Swampscott and Nahant,	4,112	324,000	79
Taunton,	26,764	1,099,000	41
Waltham,	20,443	1,239,000	61
Ware,	7,590	210,000	28
Watertown and Belmont,	10 339	414,000	40
Webster,†	7,637	219 000	29
Wellesley,	4,103	186,000	45
Whitman,	5,486	196,000	36
Woburn,	14,041	972,000	69

* May 1 to December 31.

† February 20 to December 31.

RAINFALL.

The rainfall for the year 1894 was 8.84 inches less than the normal. The greatest deficiency occurred in March and August, and there was a very marked deficiency also in June and July. There was an excess in only three of the months, May, October and December, and the excess for May was very slight. The effect of this distribution was to cause the flow in the streams to be less than normal in every month of the year.

The average annual rainfall * in Massachusetts, as deduced from long-continued observations in various parts of the State, is 45.14 inches. In the following table is given the normal rainfall for each month in the year, the rainfall for each month in 1894, and the departures from the normal.†

	Normal Rainfall. Inches.	Rainfall, 1894. Inches.	Excess or Deficiency Inches.		Normal Rainfall. Inches.	Rainfall, 1894. Inches.	Excess or Deficiency. Inches.
1894.				1894.			
January, . .	3.99	3.30	—0.69	August, . .	4.42	1.62	—2.80
February, . .	3.74	3.21	—0.53	September, . .	3.31	3.23	—0.08
March, . . .	4.05	1.29	—2.76	October, . .	3.87	5.37	+1.50
April, . . .	3.32	2.88	—0.44	November, . .	3.96	3.69	—0.27
May, . . .	3.73	3.84	+0.11	December, . .	3.57	4.33	+0.76
June, . . .	3.30	1.22	—2.08	Totals, . .	45.14	36.30	—8.84
July, . . .	3.88	2.32	—1.56				

To enable the condition preceding the collection of samples of water in any part of the State to be understood, the following tables are presented, which give the daily rainfall in inches at nine stations scattered about the State.

* Including melted snow.

† This and subsequent tables of rainfall have been prepared from the records of the New England Weather Service.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected.

January, 1894.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-	-
5, . .	0.03	0.05	0.10	0.05	0.02	*	*	-	0.02
6, . .	0.05	*	0.03	0.06	0.04	0.22	0.08	-	*
7, . .	0.07	0.18	-	-	-	0.02	0.04	-	0.07
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	0.11	*	0.12	*	0.17	*	*	*	*
11, . .	0.05	0.25	0.04	0.14	-	0.15	0.23	0.10	0.07
12, . .	-	-	-	0.05	-	0.04	0.08	0.15	0.20
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	0.01	0.02	-	-	-	-	-
15, . .	*	*	-	*	*	*	-	*	*
16, . .	0.28	0.20	0.09	0.23	0.30	0.28	0.29	0.30	0.28
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	0.12	-	-	*	-	-	-	-
19, . .	0.12	-	0.12	0.18	0.14	0.14	0.12	0.17	0.21
20, . .	-	-	-	-	-	-	-	-	-
21, . .	0.02	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	0.19	0.39	0.25	0.45	*	*	*	*	*
25, . .	0.32	-	0.09	-	0.43	0.24	0.35	0.40	0.55
26, . .	*	*	-	*	*	*	*	*	-
27, . .	0.23	0.53	0.35	1.28	1.30	0.65	0.78	1.30	2.28
28, . .	-	-	-	-	-	-	-	-	-
29, . .	0.15	*	0.30	0.95	*	*	0.99	0.10	*
30, . .	0.70	0.88	1.49	0.82	1.50	1.26	0.47	0.10	1.45
31, . .	-	-	-	-	-	-	-	-	-
Totals,	2.32	2.60	2.99	4.23	3.90	3.00	3.43	2.62	5.13

February, 1894.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.10	-	-	0.03	-	-	-	-	0.05
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	*	*	0.04	0.28	*	*	*	0.20	*
5, . .	0.60	0.03	0.10	-	0.23	0.20	0.18	-	0.29
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	0.01	-	-	0.02	-	-	-
9, . .	0.32	*	0.30	*	*	*	*	*	*
10, . .	0.33	0.49	0.71	0.73	0.68	*	0.89	0.55	0.55
11, . .	*	-	-	-	-	0.69	-	-	-
12, . .	0.10	*	0.35	*	*	*	*	0.30	*
13, . .	0.10	0.63	0.81	1.43	1.20	0.89	0.58	0.90	0.90
14, . .	*	*	-	*	-	-	-	*	*
15, . .	0.45	0.64	0.99	0.80	0.95	1.11	0.99	0.66	1.18
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	*	-	-	-	-	-	-	-
18, . .	0.16	0.13	0.32	0.29	0.36	0.13	0.14	0.41	0.53
19, . .	0.13	-	-	*	*	0.04	*	*	*
20, . .	-	-	-	0.21	0.35	-	0.16	0.34	0.44
21, . .	-	-	-	-	-	0.02	-	-	0.03
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	0.08	-	-	0.14	0.04	-	-	0.80	*
27, . .	-	-	-	-	-	-	-	-	0.52
28, . .	-	-	-	-	-	-	-	-	-
Totals,	2.37	1.92	3.63	3.91	3.81	3.10	2.94	4.16	4.49

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

March, 1894.									
Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	0.01	-	-	-	-	-	-	0.02
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	0.02	-	-	-	-	-
10, . .	-	-	-	-	-	-	0.01	-	*
11, . .	0.10	-	-	0.03	-	-	*	-	0.05
12, . .	-	-	-	-	-	-	0.01	-	-
13, . .	0.05	0.11	*	*	-	*	-	-	-
14, . .	-	-	0.08	0.10	0.12	0.17	0.16	0.06	0.18
15, . .	0.27	0.19	0.02	0.16	0.15	0.07	-	0.10	*
16, . .	-	-	-	-	-	-	0.03	-	0.13
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	0.10	0.08	0.01	0.05	0.04	0.04	0.05	0.10	*
22, . .	0.10	*	0.01	*	*	*	*	*	0.20
23, . .	0.30	1.06	0.64	0.83	0.57	0.57	0.60	0.46	0.49
24, . .	-	-	-	-	-	-	-	-	-
25, . .	0.05	-	0.01	*	*	*	*	*	*
26, . .	0.05	-	0.01	0.05	0.04	0.21	0.05	0.12	0.21
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	0.10	-	0.03	0.17	0.22	*	*	0.42	*
30, . .	-	-	-	-	-	0.08	0.16	-	0.60
31, . .	-	-	-	-	-	-	-	-	-
Totals,	1.12	1.45	0.81	1.41	1.14	1.14	1.07	1.26	1.88

April, 1894.									
Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	0.20	0.25	0.26	0.38	0.43	*	*	1.30	*
5, . .	0.10	-	-	-	-	0.29	0.38	-	1.80
6, . .	0.10	-	0.03	*	0.02	-	0.02	0.12	0.08
7, . .	0.10	*	-	*	*	-	-	*	*
8, . .	0.60	0.53	0.79	*	*	*	*	0.80	*
9, . .	-	-	-	0.90	1.08	0.61	0.97	0.06	0.67
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.10	*	0.23	*	*	*	*	*	*
12, . .	0.05	0.16	0.55	*	*	*	*	0.70	1.10
13, . .	0.05	-	-	1.42	*	*	*	0.06	*
14, . .	-	-	-	-	1.41	0.72	1.06	0.28	0.38
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	*	-	-	-	-	-	-	*
20, . .	0.05	*	-	-	-	-	-	0.03	0.05
21, . .	0.25	*	0.30	0.20	0.08	0.05	0.02	0.14	*
22, . .	0.20	0.60	0.32	0.01	-	0.07	0.03	-	0.13
23, . .	-	-	-	-	-	-	-	-	-
24, . .	0.10	-	0.27	0.37	0.22	0.28	*	0.15	0.30
25, . .	-	-	-	-	-	-	0.21	-	0.40
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	0.04	-	-	-	-	-	-	-
28, . .	0.10	-	-	-	-	-	-	0.06	0.20
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
Totals,	2.00	1.58	2.75	3.28	3.24	2.02	2.69	3.70	5.11

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

May, 1894.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	0.12	-	-	-	-	-	-	0.09	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	0.08	*	0.14	0.11	0.26	*	*	0.02	0.01
5, . .	-	0.22	-	-	*	0.34	0.24	-	-
6, . .	0.25	0.20	0.31	0.30	0.30	0.17	0.50	0.27	0.28
7, . .	0.07	0.02	-	0.01	-	-	-	0.05	0.07
8, . .	-	-	0.03	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.05	0.11	0.03	0.03	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	0.05	-	0.03	*	-	-	0.01	*	0.02
19, . .	0.56	-	0.40	0.78	0.65	-	0.88	0.18	0.42
20, . .	0.15	1.22	0.68	*	*	-	*	0.15	0.02
21, . .	-	-	0.04	0.31	0.07	0.83	0.23	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	0.42	-	0.06	*	*	-	0.03	*	*
24, . .	0.38	-	1.00	0.98	0.95	-	*	1.00	*
25, . .	0.16	0.85	0.14	0.06	0.05	0.95	1.71	0.10	1.95
26, . .	-	-	-	0.02	-	-	-	0.28	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	*	-	-	-	-	-	-	-	-
29, . .	0.62	-	0.80	1.52	1.17	1.32	0.40	0.55	0.78
30, . .	-	-	-	-	-	-	-	-	-
31, . .	0.38	0.97	0.40	0.45	0.82	0.39	0.78	1.14	1.05
Totals,	3.29	3.59	4.06	4.37	4.27	4.00	4.78	3.83	4.60

June, 1894.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	0.03	-	-	-	-	-	0.22
2, . .	0.20	0.68	0.31	*	*	*	*	0.10	*
3, . .	0.10	-	-	0.32	0.15	0.54	0.18	-	0.03
4, . .	0.05	-	0.02	-	-	-	-	*	0.01
5, . .	-	-	-	-	-	-	-	0.10	0.01
6, . .	-	-	-	-	-	-	-	0.18	0.06
7, . .	0.01	-	-	-	-	-	-	0.10	0.05
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	0.02	0.20	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	0.08	0.56	-	-	-	-	-	-	-
20, . .	0.12	-	0.16	-	-	-	0.02	-	*
21, . .	-	-	0.01	0.55	0.05	-	0.26	0.10	0.01
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	0.26	0.04	-	-	-	-	*
24, . .	-	-	0.47	-	-	-	-	-	0.04
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	0.01
28, . .	-	-	-	-	-	-	0.16	-	0.03
29, . .	-	-	0.02	-	-	-	-	-	*
30, . .	1.45	1.28	0.33	-	-	-	-	0.15	0.30
Totals,	2.01	2.52	1.63	1.11	0.20	0.54	0.62	0.73	0.77

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

July, 1894.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	*	0.11
2, . .	-	-	-	-	-	-	-	*	-
3, . .	0.02	0.13	0.10	0.29	0.13	-	0.34	0.90	0.06
4, . .	0.02	0.06	-	0.22	-	0.37	-	-	-
5, . .	-	-	-	-	-	-	-	-	0.04
6, . .	-	0.07	-	-	-	-	-	-	-
7, . .	0.01	-	-	-	-	-	-	0.10	-
8, . .	0.05	-	-	-	-	-	-	-	-
9, . .	-	0.02	-	-	-	-	-	-	-
10, . .	-	-	0.08	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	0.05	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	0.35	0.10	0.05	0.18	0.07	*	-	0.28	0.08
15, . .	0.05	-	-	-	-	0.61	0.05	*	-
16, . .	0.02	0.01	-	0.15	-	-	-	1.00	0.04
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	0.55	*	0.39	0.18	1.13	*	0.12	-	-
22, . .	0.52	0.50	0.38	0.51	0.31	0.76	0.68	0.08	0.02
23, . .	-	*	-	-	-	-	-	-	-
24, . .	0.04	0.15	0.29	0.93	0.80	0.99	1.43	0.22	0.45
25, . .	-	0.16	-	1.14	0.82	0.47	0.39	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	0.35	0.03	.044	0.22	0.07	1.05	-	-	-
30, . .	-	-	-	-	-	-	0.05	-	-
31, . .	-	-	-	-	-	-	-	0.06	-
Totals,	2.03	1.23	1.73	3.82	3.33	4.25	3.06	2.64	0.80

August, 1894.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	0.02	*	-	-	-	-	-	-	-
3, . .	0.45	0.16	0.51	0.72	0.12	0.54	0.26	0.38	0.02
4, . .	-	-	-	0.04	0.03	-	0.03	0.08	1.20
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	0.06	-	-	*	-	-	-	*	-
9, . .	0.04	-	0.06	0.16	0.27	0.12	0.25	0.03	0.07
10, . .	-	-	-	-	0.10	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	0.01	-	-	-	-	-	-
13, . .	0.03	0.13	-	*	0.25	-	0.17	0.44	0.38
14, . .	-	-	-	0.28	0.10	-	*	-	0.03
15, . .	0.12	0.04	-	0.04	-	0.17	0.03	-	-
16, . .	-	-	-	-	-	-	-	-	0.20
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	0.07	0.01	-	0.70	-	-	0.52	0.61	0.06
21, . .	-	-	-	-	1.40	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	-
30, . .	0.05	0.04	-	-	-	-	-	-	0.02
31, . .	-	-	-	-	-	-	-	-	-
Totals,	0.84	0.38	0.58	1.94	2.27	0.83	1.26	1.54	1.98

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

September, 1894.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	–	–	–	–	–	–	–	–	–
2, . .	–	–	–	–	–	–	–	–	–
3, . .	–	–	–	–	–	–	–	–	–
4, . .	–	–	–	–	–	–	–	–	–
5, . .	–	–	–	–	–	–	–	–	–
6, . .	0.40	0.14	0.03	0.17	0.05	–	0.05	–	–
7, . .	–	–	–	0.19	–	–	–	–	–
8, . .	0.37	*	0.22	–	0.34	*	*	0.36	0.06
9, . .	–	0.47	–	–	–	0.32	0.48	–	–
10, . .	0.10	0.30	0.65	–	0.02	0.45	–	0.07	0.04
11, . .	–	–	–	–	–	–	–	–	–
12, . .	–	–	–	–	–	–	–	–	–
13, . .	–	–	–	–	–	–	–	–	–
14, . .	0.10	*	–	–	–	–	–	–	–
15, . .	0.06	0.22	0.21	0.03	0.12	0.12	–	0.24	0.78
16, . .	0.50	1.27	0.21	–	–	*	–	0.04	0.02
17, . .	0.30	–	0.99	0.49	0.15	0.56	0.35	0.05	0.02
18, . .	–	–	–	–	–	–	–	–	0.01
19, . .	0.10	*	0.50	*	*	*	*	0.71	*
20, . .	1.49	1.93	0.64	1.80	1.82	1.35	1.40	1.82	1.91
21, . .	–	0.38	–	–	–	–	–	–	–
22, . .	–	–	–	–	–	–	–	–	–
23, . .	–	–	–	–	–	–	–	–	–
24, . .	–	–	–	–	–	–	–	–	–
25, . .	–	–	–	–	–	–	–	–	–
26, . .	–	–	–	–	–	–	–	–	–
27, . .	–	–	–	–	–	–	–	–	–
28, . .	–	–	–	–	–	–	–	–	–
29, . .	–	–	–	–	–	–	–	–	–
30, . .	–	–	0.10	0.10	–	–	–	–	0.07
Totals,	3.42	4.71	3.55	2.78	2.50	2.80	2.28	3.29	2.91

October, 1894.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	–	–	–	–	–	–	–	–	0.13
2, . .	–	–	–	–	–	–	–	–	–
3, . .	0.03	*	0.01	–	–	–	–	0.04	0.04
4, . .	0.85	*	0.51	*	*	*	0.16	*	*
5, . .	0.22	1.07	0.06	0.46	0.46	0.38	0.21	0.62	0.59
6, . .	–	–	–	–	–	–	–	–	–
7, . .	–	–	–	–	–	–	–	–	–
8, . .	–	–	–	*	–	–	–	*	–
9, . .	*	0.04	0.02	0.06	0.31	0.05	0.30	1.38	0.46
10, . .	1.14	*	1.66	1.50	1.72	1.15	1.74	1.46	1.35
11, . .	0.05	1.24	–	–	–	–	–	–	–
12, . .	–	*	–	–	–	–	–	–	–
13, . .	0.35	0.30	0.21	*	*	*	*	*	*
14, . .	0.10	–	–	0.75	1.32	0.88	0.96	1.90	0.97
15, . .	–	–	–	–	–	–	–	–	–
16, . .	–	–	–	–	–	–	–	–	–
17, . .	–	–	–	–	–	–	–	–	–
18, . .	–	–	–	–	–	–	–	–	–
19, . .	–	–	–	–	–	–	–	–	–
20, . .	–	–	–	–	–	–	–	–	–
21, . .	–	–	–	–	–	–	–	–	–
22, . .	–	–	–	–	–	–	–	–	–
23, . .	–	–	–	–	–	–	–	–	–
24, . .	0.24	*	0.10	–	–	*	–	–	–
25, . .	0.08	*	0.07	*	*	*	*	0.92	*
26, . .	0.48	0.75	0.75	1.69	1.71	0.77	1.33	0.38	3.70
27, . .	–	–	–	–	–	–	–	–	–
28, . .	–	–	–	–	–	–	–	–	–
29, . .	–	–	–	–	–	–	–	–	–
30, . .	*	*	0.08	*	*	*	*	*	*
31, . .	0.49	0.62	0.97	0.74	0.52	0.56	0.75	0.58	0.39
Totals,	4.03	4.02	4.44	5.20	6.04	3.79	5.45	7.28	7.63

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Concluded.

November, 1894.										December, 1894.									
Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.	Day of Month.	Ludlow.†	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, .	-	-	-	-	-	-	-	-	-	1, .	*	*	-	-	-	-	-	-	*
2, .	-	-	-	-	-	-	-	-	-	2, .	0.53	0.69	0.36	0.52	0.47	*	*	-	*
3, .	1.10	1.18	1.07	0.60	0.60	0.44	0.32	0.45	0.62	3, .	-	-	-	-	-	0.44	0.45	-	0.74
4, .	-	*	-	-	-	-	-	-	-	4, .	-	-	-	-	-	-	-	-	-
5, .	1.03	1.05	1.20	*	*	*	-	*	*	5, .	-	-	-	-	-	-	-	-	-
6, .	0.82	-	0.29	1.26	1.43	1.12	1.98	1.36	2.05	6, .	-	-	-	-	-	-	-	-	-
7, .	0.20	-	-	-	-	-	-	-	-	7, .	-	-	-	-	-	-	-	-	-
8, .	-	*	0.26	0.38	0.37	*	*	0.34	*	8, .	*	*	0.10	*	*	*	*	*	*
9, .	-	*	-	*	*	0.23	0.31	0.05	*	9, .	0.72	0.55	0.75	*	0.78	*	0.62	0.46	*
10, .	0.30	0.52	0.29	0.28	0.30	0.23	0.06	0.45	0.51	10, .	-	-	0.02	0.62	-	0.52	-	*	0.64
11, .	-	-	-	-	-	-	0.47	-	-	11, .	*	-	0.14	*	*	*	*	0.06	*
12, .	-	-	-	-	-	-	-	-	-	12, .	1.24	1.27	0.55	0.90	0.94	0.38	*	0.75	0.36
13, .	-	*	0.04	*	-	*	*	0.02	0.05	13, .	-	-	-	-	-	-	0.73	-	-
14, .	0.04	0.05	-	0.16	0.17	0.12	0.02	0.17	0.12	14, .	-	-	-	-	-	-	-	-	-
15, .	-	-	-	-	-	-	0.08	-	-	15, .	-	-	-	-	-	-	-	-	-
16, .	-	-	-	-	-	-	-	-	-	16, .	-	-	-	-	-	-	-	-	-
17, .	0.08	-	0.05	0.08	0.11	0.02	0.11	0.29	0.30	17, .	-	-	-	-	-	-	-	-	-
18, .	-	-	-	-	-	-	-	-	-	18, .	-	-	-	-	-	-	-	-	-
19, .	0.12	-	0.12	-	-	0.07	-	-	0.09	19, .	-	-	-	-	-	-	-	-	-
20, .	-	-	-	0.41	-	-	-	-	-	20, .	-	-	-	-	-	-	-	-	-
21, .	0.17	0.24	0.30	-	0.21	*	*	0.33	0.29	21, .	-	-	-	-	-	-	-	-	-
22, .	-	-	-	-	-	0.33	0.11	-	-	22, .	-	0.06	-	-	-	-	-	-	-
23, .	0.06	-	0.01	-	-	*	-	0.07	0.02	23, .	-	-	-	-	-	-	-	-	-
24, .	-	-	-	-	-	0.03	-	-	0.04	24, .	*	0.14	-	*	-	-	-	*	-
25, .	0.08	-	-	0.16	0.12	0.08	0.14	0.11	0.05	25, .	0.22	-	0.03	0.24	0.22	-	0.15	0.37	0.73
26, .	-	-	-	-	-	-	-	-	-	26, .	*	*	*	*	*	0.04	-	*	*
27, .	-	-	-	-	-	-	-	0.08	0.01	27, .	1.20	1.34	1.33	2.53	1.65	1.77	2.36	2.75	3.07
28, .	-	-	-	-	-	-	-	-	-	28, .	-	-	-	-	-	-	-	-	-
29, .	-	-	-	-	-	-	-	-	-	29, .	-	-	-	-	-	-	-	-	0.03
30, .	0.07	-	0.05	0.10	0.10	0.06	0.08	-	0.10	30, .	-	-	-	-	-	-	-	-	-
										31, .	-	-	-	-	-	-	-	-	-
Tot.,	4.07	3.04	3.68	3.43	3.41	2.73	3.68	3.72	4.25	Tot.,	3.91	4.05	3.28	4.81	4.06	3.15	4.31	4.39	5.57
Totals for the Year, ...											31.41	31.09	33.13	40.29	38.17	31.35	35.57	39.16	45.12

* Precipitation included in that of following day.

† Estimated from records of adjacent stations; no daily distribution given for Ludlow.

Flow of Streams.

The records of the flow of the Sudbury River for 1894 indicate that the flow of the streams of the State was slightly less than for the year 1892, and was, with two exceptions, the least during the past twenty years, the flow for the year being 73 per cent. of the average. The drier years were 1880 and 1883, and the corresponding percentages were respectively 55 and 50. The flow was below the average in every month of the year, the deficiency being most marked in the first five months. The conditions resembled strongly those existing in 1892, in that the flow of the streams was nearly the same, and in each case the last seven months of the preceding year were very dry.

The effect upon communities which derive their supplies from large ponds fed by small water-sheds was much the same as in 1892, and the ponds were drawn in many cases to a lower level than ever before; but much greater inconvenience was caused than in 1892 to those communities which derive their supply from large water-sheds with comparatively small storage, from which water usually runs to waste in the spring, and which are to a considerable degree dependent for their supplies upon the summer flow of the streams, owing to the small flow during the summer months. The flow of the Sudbury River for the four months from June to September, 1894, was very nearly the same as that for the corresponding months of 1893.

Table showing the Average Monthly Flow of Sudbury River for the Year 1894, in Cubic Feet per Second per Square Mile of Drainage Area, also Departures from the Normal Flow.

Month.	Normal Flow. Cubic Feet per Second per Square Mile.	Actual Flow in 1894. Cubic Feet per Second per Square Mile.	Excess or Deficiency. Cubic Feet per Second per Square Mile.
January,	1.888	1.072	—0.816
February,	2.955	1.533	—1.422
March,	4.403	3.463	—0.940
April,	3.141	2.538	—0.603
May,	1.816	1.299	—0.517
June,	0.755	0.648	—0.107
July,	0.286	0.249	—0.037
August,	0.447	0.324	—0.123
September,	0.383	0.231	—0.152
October,	0.778	0.579	—0.199
November,	1.329	1.293	—0.036
December,	1.548	1.108	—0.440
Average,	1.637	1.192	—0.445

This table has been prepared in order to show the relation between the flow of the Sudbury River during each month of 1894

and the normal flow of the same river as deduced from twenty years' observations, from 1875 to 1894 inclusive. The area of the watershed of the Sudbury River above the point of measurement is 75.2 square miles.

The next table shows the weekly fluctuations, during 1894, in the flow of the two streams most carefully measured, namely, the Sudbury and the Merrimack. The flow of these streams, particularly the Sudbury, will serve to indicate the condition of other streams in eastern Massachusetts: —

Table showing the Average Weekly Flow of the Sudbury and Merrimack Rivers, in Cubic Feet per Second per Square Mile of Drainage Area, for the Year 1894.

Week ending Sunday —	Sudbury River. Cubic Feet per Second per Square Mile.	Merrimack River. Cubic Feet per Second per Square Mile.	Week ending Sunday —	Sudbury River. Cubic Feet per Second per Square Mile.	Merrimack River. Cubic Feet per Second per Square Mile.
Jan. 7,	1.249	0.858	July 8,	0.198	0.533
14,	0.905	0.999	15,	0.009	0.511
21,	0.947	0.820	22,	0.111	0.453
28,	1.151	0.666	29,	0.424	0.451
Feb. 4,	1.143	0.845	Aug. 5,	0.418	0.408
11,	1.134	0.629	12,	0.174	0.390
18,	1.514	1.142	19,	0.035	0.367
25,	2.351	1.560	26,	0.326	0.336
Mar. 4,	2.192	1.296	Sept. 2,	0.045	0.329
11,	7.145	3.900	9,	0.073	0.266
18,	3.039	3.768	16,	—0.114	0.394
25,	2.486	3.364	23,	0.429	0.504
Apr. 1,	1.804	2.336	30,	0.004	0.480
8,	1.585	1.869	Oct. 7,	0.094	0.399
15,	3.716	2.025	14,	0.656	0.464
22,	3.388	2.430	21,	0.254	0.581
29,	2.110	3.386	28,	0.764	0.459
May 6,	1.226	1.793	Nov. 4,	0.986	0.579
13,	0.736	1.363	11,	1.747	1.000
20,	0.740	0.810	18,	1.279	0.713
27,	1.612	1.580	25,	1.106	0.750
June 3,	2.449	2.703	Dec. 2,	0.963	0.593
10,	0.828	2.249	9,	0.754	0.541
17,	0.301	1.012	16,	1.547	0.731
24,	0.418	0.702	23,	1.503	0.864
July 1,	0.200	0.715	30,	1.081	0.560

In the annual report of the State Board of Health for the year 1890 (pages 338 to 340) a table was printed giving records of the rainfall upon the Sudbury River water-shed and its yield, expressed in inches in depth upon the water-shed (inches of rainfall collected), for the sixteen years from 1875 to 1890 inclusive. The corresponding records for the years 1891 and 1892, as taken from the annual reports of the Boston Water Board, were given in the annual report for 1892, and the record for the year 1893 in the annual report for that year. In the following table is given the record for 1894, together with the average of the records for the whole twenty years: —

Rainfall Received and Collected on the Sudbury River Water-shed.

MONTH.	1894.			MEAN FOR 20 YEARS, 1875-1894.		
	Rainfall.	Rainfall Collected.	Per Cent. Collected.	Rainfall.	Rainfall Collected.	Per Cent. Collected.
January,	4.090	1.236	30.22	4.338	2.177	50.18
February,	3.910	1.596	40.82	4.273	3.104	72.64
March,	1.435	3.992	278.19	4.445	5.076	114.20
April,	3.415	2.832	82.93	3.244	3.505	108.05
May,	4.235	1.498	35.37	3.485	2.093	60.06
June,	1.155	0.723	62.60	2.891	0.842	29.12
July,	3.255	0.287	8.82	3.700	0.330	89.19
August,	2.030	0.373	18.37	4.212	0.515	12.23
September,	2.635	0.258	9.79	3.065	0.427	13.93
October,	5.345	0.668	12.50	4.250	0.897	21.11
November,	3.425	1.442	42.10	4.011	1.483	36.97
December,	4.810	1.277	26.55	3.692	1.785	48.35
TOTALS AND AVERAGES,	39.740	16.182	40.72	45.606	22.234	48.75

The Sudbury River records are particularly valuable as a basis for estimating the yield of other water-sheds in Massachusetts, both on account of the accuracy with which the measurements have been made during the whole twenty years, and the absence of abnormal conditions which would unfavorably affect the results. It is therefore thought advisable to publish in the following table those portions of the records relating to the yield of this water-shed for each of the twenty years; and in doing so the flow from the water-shed is expressed in gallons per day per square mile, instead of inches in depth of rainfall collected, in order to render the table more convenient for use in estimating the probable yield of water-sheds used as sources of water supply.

*Yield of the Sudbury River Water-shed in Gallons Per Day Per Square Mile.**

MONTH.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
January,	103,000	643,000	658,000	1,810,000	700,000	1,121,000	415,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000
March,	1,604,000	4,435,000	4,813,000	3,507,000	2,330,000	1,374,000	4,004,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,168,000	1,546,000
May,	1,188,000	1,139,000	1,391,000	1,394,000	1,114,000	514,000	965,000
June,	870,000	222,000	597,000	506,000	413,000	176,000	1,338,000
July,	321,000	183,000	202,000	128,000	158,000	177,000	276,000
August,	396,000	405,000	121,000	475,000	395,000	119,000	148,000
September,	207,000	184,000	60,000	160,000	141,000	80,000	197,000
October,	646,000	234,000	632,000	516,000	71,000	101,000	186,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000
December,	584,000	454,000	1,289,000	3,177,000	462,000	175,000	775,000
Average for whole year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000
Av'ge for driest six months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000

MONTH.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
January,	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000
February,	2,403,000	1,033,000	2,842,000	1,354,000	4,800,000	2,829,000	1,951,000
March,	2,839,000	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,237,000
April,	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000
May,	1,292,000	938,000	1,030,000	1,336,000	720,000	1,009,000	1,632,000
June,	529,000	300,000	417,000	426,000	203,000	414,000	422,000
July,	86,000	115,000	224,000	62,000	115,000	114,000	117,000
August,	55,000	78,000	257,000	240,000	94,000	214,000	380,000
September,	306,000	91,000	44,000	121,000	118,000	111,000	1,155,000
October,	299,000	186,000	83,000	336,000	146,000	190,000	1,999,000
November,	210,000	205,000	175,000	1,178,000	673,000	368,000	2,758,000
December,	314,000	193,000	925,000	1,174,000	1,020,000	643,000	3,043,000
Average for whole year,	862,000	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000
Av'ge for driest six months,	211,000	145,000	200,000	391,000	223,000	234,000	953,000

MONTH.	1889.	1890.	1891.	1892.	1893.	1894.	Mean for 20 Years, 1875-1894, inclusive.
January,	2,782,000	1,254,000	3,018,000	1,870,000	433,000	693,000	1,220,000
February,	1,195,000	1,529,000	3,486,000	943,000	1,542,000	991,000	1,910,000
March,	1,339,000	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000	2,845,000
April,	1,410,000	1,875,000	2,397,000	871,000	2,125,000	1,640,000	2,030,000
May,	880,000	1,366,000	582,000	1,259,000	2,883,000	840,000	1,174,000
June,	653,000	568,000	414,000	428,000	440,000	419,000	488,000
July,	633,000	108,000	149,000	214,000	158,000	161,000	185,000
August,	1,432,000	132,000	163,000	280,000	181,000	209,000	289,000
September,	824,000	458,000	203,000	229,000	108,000	150,000	247,000
October,	1,230,000	2,272,000	210,000	126,000	221,000	374,000	503,000
November,	1,941,000	1,215,000	305,000	697,000	319,000	836,000	859,000
December,	2,241,000	997,000	544,000	485,000	797,000	716,000	1,000,000
Average for whole year,	1,383,000	1,285,000	1,315,000	781,000	1,037,000	770,000	1,058,000
Av'ge for driest six months,	944,000	747,000	239,000	327,000	237,000	356,000	395,000

* The area of the Sudbury River water-shed used in making up these records included water surfaces amounting to about one per cent. of the whole area, from 1875 to 1878 inclusive, and subsequently increasing by the construction of storage reservoirs to about three per cent. in 1886. The water-shed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

THE COMPOSITION

OF THE

WATER OF DEEP WELLS

IN

BOSTON AND VICINITY.

By THOMAS M. DROWN, M.D., Chemist of the Board.

THE COMPOSITION OF THE WATER OF DEEP WELLS IN BOSTON AND VICINITY.

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There are a great many wells in and around Boston of private ownership, mostly in connection with factories, the waters of which are variously used for drinking or manufacturing purposes. The wells vary in depth from comparatively shallow wells of 80 to 100 feet to deep wells of over 1,000 feet.

It was thought desirable to ascertain the composition of these waters, not only with reference to their sanitary quality, but also as regards their mineral contents.

The consent of all the owners of these wells was cheerfully given to collect samples for analysis, and information was also furnished regarding the depth of the wells, but other details, such as the character of the soils or rocks through which the wells were sunk, were not generally known. The results of the analyses and the depths of the wells are given in tables which follow.

In the area embracing these wells there are two important rock formations, — the conglomerate, which is limited to the Highland district in Roxbury, and the slate, which underlies Boston proper, South Boston, Charlestown, Cambridge, etc. The conglomerate is found at most points quite near the surface, while the slate, being more deeply eroded, is usually covered by from 50 to 200 or more feet of drift, chiefly stratified clay. The character of the strata passed through in sinking the wells in the slate region is not certainly known, but it is not unlikely that the two 1,200-foot wells in South Boston pass through the slate into the underlying conglomerate.*

* I am indebted to Prof. W. O Crosby, of the Massachusetts Institute of Technology, for the statement of the geology of this region.

The mineral analyses include the determination of silica, alumina, oxide of iron, oxide of manganese, lime, magnesia and sulphuric acid. No determinations of alkalies were made. It is probable that sufficient sodium is always present in these waters to combine with all the chlorine. The sulphuric acid may be assumed to be entirely combined with lime, forming sulphate of lime, since it will separate out in this form when the waters are evaporated in boilers. The magnesia and the lime, over the amount needed to combine with the sulphuric acid, are probably present as bicarbonates.

In the use of these waters for boilers the sulphates and carbonates of lime and magnesia, the oxides of iron and manganese, the alumina and silica all contribute to the formation of scale, the sulphate of lime being the most objectionable in this respect, since it forms a hard, stony scale, difficult to remove from the boiler.

There is a general similarity in the waters from the Roxbury district, notwithstanding the fact that wells vary in depth from 28 feet to nearly 800 feet. Coincident high chlorine and nitrates point to considerable previous organic contamination by surface drainage, and the low ammonias and oxygen consumed indicate that the processes of purification have been in most cases nearly complete.

Thus sixteen out of the twenty-one wells examined in the Roxbury district contained from 2.10 parts of chlorine per 100,000 to 5.99 parts, a range commonly met with in wells which have received sewage or house drainage, and all of these waters contained a considerable amount of nitrates, which confirms the theory that these wells receive surface drainage of a populous region. Five of the wells of this region have chlorine from 13.64 to 50.40 parts per 100,000, with correspondingly high solids and hardness. Without definite knowledge of the origin of this abnormally large amount of mineral matters in these five wells, it may be suggested that manufacturing wastes of some kind are the cause.

It is fair to assume that the analyses given of the sixteen wells above mentioned represent the general character of the water in this conglomerate. They correspond closely — in solids, hardness, chlorine and nitrates — with the waters from many town pumps and wells in districts with large population, also with underdrains of sewers in populous districts before sewage has been admitted to them, showing satisfactorily that there is in these wells a considerable amount of previous pollution from house drainage or sewage. Most of the waters, as mentioned above, show by their

low ammonias and oxygen consumed, that the greater part of the organic matter originally present has been destroyed by oxidation.

Of the wells in Cambridge and Charlestown, all, with one exception, show a much larger amount of chlorine, solids and hardness than can be attributed to sewage, and we must assume that these are due to sea water, either from direct infiltration or from fossil sea water of high antiquity in the rocks. This view of the origin of these mineral matters is also supported by the general absence of nitrates in these waters.

The waters represented by samples Nos. 12258, 12814, 12201 and 12290 of the South End group and 12200 of the Back Bay group have the same general character as those in Charlestown, and infiltration of sea water is here, without doubt, the origin of the high solids. Here, too, we have the almost complete absence of nitrates.

The wells examined in Boston proper, South Boston and those from which samples Nos. 12198, 12199 and 12242 at the South End were collected showed an amount of solids and chlorine greater than those in the Roxbury district, but much less than in the Back Bay, other portions of the South End and Charlestown. The fact that the nitrates are generally low or absent in these waters would point to an absence of sewage pollution, unless it be assumed that the nitrates have been reduced to free ammonia, which is present in all of them. The waters of many of these wells, particularly in the Boston and Charlestown groups, contain considerable iron in solution in the form of protoxide. These waters are clear and colorless as they come from the ground but quickly become turbid (milky) on exposure to the air, and ultimately deposit a rusty sediment. The turbidity as recorded in the tables refers to the water which has been more or less exposed to the air for about twenty-four hours.

For a more satisfactory discussion of these well waters a special investigation into the surroundings of each well and of the strata through which it passes would be necessary. With our present limited knowledge of the subject the above general considerations as to the origin of these waters must serve to interpret the analyses.

In connection with the mineral analyses of these waters it will be interesting to consult a paper on "The Mineral Contents of Some Natural Waters in Massachusetts," in the 24th annual report of the Board.

CHEMICAL EXAMINATION OF WATER FROM

Roxbury Group.

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.	Ammonia.		Chlorine.
			Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Albuminoid.	
		1894.									
1	12079	Apr. 23	V. slight.	Cons., floc.	0.00	None.	None.	100.30	.0066	.0042	33.60
2	12080	Apr. 23	None.	None.	0.00	None.	None.	56.50	.1920	.0040	13.64
3	12082	Apr. 23	None.	V. slight.	0.00	None.	None.	25.50	.0012	.0014	2.55
4	12185	May 10	None.	None.	0.00	None.	None.	80.90	.0000	.0012	24.42
5	12815	Aug. 24	None.	None.	0.02	None.	None.	89.50	.0000	.0014	25.90
6	12812	Aug. 24	None.	None.	0.00	None.	Faint.	34.50	.0000	.0020	3.70
7	12810	Aug. 24	Distinct, clayey.	Cons., earthy.	0.10	None.	Faintly earthy.	33.50	.0000	.0026	3.00
8	12811	Aug. 24	None.	Slight.	0.00	None.	None.	22.90	.0000	.0008	2.20
9	12086	Apr. 23	V. slight.	V. slight.	0.00	None.	None.	27.40	.0016*	.0014*	2.44
10	12085	Apr. 23	None.	None.	0.00*	None.	None.	31.20*	.0002*	.0010*	2.84
11	12119	Apr. 30	V. slight, milky.	None.	0.08	None.	None.	113.70	.0064	.0008	50.40
12	12117	Apr. 30	None.	None.	0.00	None.	None.	26.10	.0000	.0010	2.23
13	12114	Apr. 30	None.	None.	0.00	None.	None.	32.20	.0004	.0020	3.55
14	12083	Apr. 23	None.	V. slight.	0.00	None.	None.	39.20	.0050	.0058	5.99
15	12116	Apr. 30	None.	None.	0.00	None.	None.	26.30	.0002	.0028	2.10
16	12118	Apr. 30	None.	None.	0.00	None.	None.	27.90	.0018	.0022	5.65
17	12115	Apr. 30	None.	None.	0.00	None.	None.	17.40	.0002	.0000	2.24
18	12813	Aug. 24	None.	None.	0.02	None.	None.	35.60	.0000	.0014	3.70
19	12087	Apr. 23	None.	V slight.	0.00*	None.	None.	34.90*	.0014*	.0018*	3.22
20	12084	Apr. 23	Distinct, milky.	Slight, rusty.	0.03	None.	Faint.	33.10	.0048	.0066	2.36
21	12081	Apr. 23	V. slight.	Slight, earthy.	0.01*	None.	None.	23.60*	.0000*	.0016*	2.35

* These determinations were made on water which had been filtered through filter-paper.

DEEP WELLS IN BOSTON AND VICINITY

Roxbury Group.

[Parts per 100,000.]

Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.	Silica.	Alumina.	Oxide of Manganese.	Alumina and Oxide of Manganese.*	Lime.	Magnesia.	Sulphuric Acid in combination with Lime.	Depth of Well. Feet.	
.5250	.0016	.1777	29.0	.0026	1.5767	.1104	.0000	–	10.6130	4.9100	5.9720	28	1
.6250	.0025	.0814	21.0	.0090	1.4433	.1000	.0000	–	7.3266	3.8133	5.8100	28	2
.5250	.0013	.0316	12.5	.1647	1.6600	.0000	.0286	–	4.3833	2.3330	2.9880	35	3
.3500	.0000	.0697	35.5	.0000	1.5950	.1450	.0000	–	11.4100	5.9900	6.7840	56	4
.0400	.0000	.0462	18.6	.0129	–	–	–	–	–	–	–	56	5
1.5500	.0000	.0000	14.9	.0039	1.0160	–	–	.0470	5.5000	2.1200	3.6223	64	6
1.6600	.0005	.0154	14.1	.0039	1.0000	–	–	.1470	5.3660	2.0477	3.9455	70	7
.5800	.0000	.0077	9.7	.0064	1.2160	–	–	.1550	3.2500	1.5555	2.2833	101	8
.7500	.0001	.0553	13.5	.0129	1.4166	.0490	.0000	–	5.4233	2.4310	4.0240	160	9
.9250	.0001	.0316*	15.0	.0026	1.8566	.0639	.0000	–	6.2830	2.6563	3.9560	187	10
.0500	.0011	.0814	20.0	.0129	1.8133	–	–	.1290	10.7067	2.3270	3.2890	315	11
.1800	.0070	.0324	14.5	.0000	1.5567	–	–	.1033	6.2767	2.2833	3.2270	400	12
1.0000	.0000	.0118	13.0	.0129	1.4133	.0324	.0000	–	5.2800	2.4267	3.6600	401	13
.9250	.0005	.0750	17.5	.0129	1.7233	.0880	.0000	–	6.1500	3.4733	4.0380	407	14
.2800	.0075	.0498	14.5	.0206	1.5833	–	–	.0171	6.3500	1.9110	2.3220	460	15
.1300	.0013	.0103	13.0	.0000	1.6767	.0400	.0000	–	5.9267	1.3763	2.4920	500	16
.2500	.0004	.0079	10.5	.0000	1.5967	–	–	.0467	3.1600	1.6323	2.4640	508	17
.5950	.0010	.0077	19.3	.0321	1.4800	–	–	.0580	5.1160	4.1020	3.7425	603	18
.5500	.0007	.0553*	19.0	.0064	1.5767	–	–	.0662	7.0000	3.2300	5.0620	650	19
.5750	.0010	.0750	17.5	.2137	1.7800	.2359	.0000	–	6.4767	3.4500	4.1300	650	20
.4400	.0018	.0403*	12.5	.0064	1.6267	.1262	.0000	–	4.5333	2.3255	2.8900	780	21

* In those analyses in which the manganese was not determined directly, it has been included with the alumina, but in none of these cases was there any considerable amount of oxide of manganese.

CHEMICAL EXAMINATION OF WATER FROM

Cambridge Group.

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.
		1894.									
1	12821	Aug. 25	None.	None.	0.00	None.	None.	264.60	.0002	.0018	103.00
2	12825	Aug. 25	V. slight.	Slight, rusty.	0.05	None.	None.	259.50	.0492	.0034	111.20
3	12849	Sept. 4	None.	None.	0.00	None.	None.	85.00	.0146	.0018	20.60

Charlestown Group.

	Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Odor. Cold.	Odor. Hot.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.
4	12262	May 21,	Decided, rusty.	Cons., rusty.	0.00	Faint or none.	Distinctly unpleasant.	712.60	.0390	.0044	303.50
5	12822	Aug. 25	Slight, milky.	Cons., rusty.	0.10*	None.	None.	777.10	.0560	.0034	335.00
6	12261	May 21	Slight, milky.	Slight.	0.00	None.	Distinctly disagree'ble, gassy.	294.40	.0224	.0024	122.00
7	12823	Aug. 25	None.	None.	0.15	None.	None.	285.00	.0212	.0022	121.00
8	12264	May 21	None.	Slight.	0.04	Faint or none.	None.	46.50	.0000	.0012	4.42
9	12263	May 21	Slight.	Slight.	0.02	Decided, gassy.	Strongly gassy.	206.70	.0084	.0004	80.90
10	12824	Aug. 25	Slight.	Slight, rusty.	0.07	None.	None.	241.00	.0106	.0018	99.70

Boston, South End, Group.

	Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Odor. Cold.	Odor. Hot.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.
11	12258	May 21	None.	None.	0.05	Faintly disagree'ble, like marsh gas.	Faint or none.	204.30	.0480	.0016	93.70
12	12814	Aug. 24	None.	None.	0.04	Sulphuretted hydrogen.	None.	202.20	.0434	.0016	90.25
13	12198	May 14	None.	Slight.	0.03	None.	None.	62.30	.0120	.0016	15.96
14	12201	May 14	None.	None.	0.05	None.	Faint or none.	157.30	.0102	.0008	67.36
15	12199	May 14	Decided, rusty.	Cons., rusty.	0.00	Disagree'ble, gassy.	Decidedly musty.	56.00	.0506	.0014	20.60
16	12290	June 1	Slight, milky.	Slight.	0.08	Sulphuretted hydrogen.	None.	172.60	.0700	.0012	77.08
17	12242	May 19	Slight, milky.	Slight.	0.08	Distinctly disagreeable.	Distinctly unpleasant.	75.70	.0400	.0010	30.80

Boston, Back Bay.

	Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Odor. Cold.	Odor. Hot.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.
18	12200	May 14	Slight.	None.	0.03	Distinct, like marsh gas.	Faint or none.	198.60	.0090	.0008	92.80

* This determination was made on water which had been filtered through filter-paper.

DEEP WELLS IN BOSTON AND VICINITY — Continued.

Cambridge Group.

[Parts per 100,000.]

Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.	Silica.	Alumina.	Oxide of Manganese.	Alumina and Oxide of Manganese.*	Lime.	Magnesia.	Sulphuric Acid in combination with Lime.	Depth of Well. Feet.	
.0700	.0025	.1232	103.0	.0064	1.6000	–	–	.2450	39.9500	14.5225	13.8712	97	1
.0000	.0025	.1617	78.6	.0643	1.5000	–	–	1.3500	26.5500	12.8288	19.5248	150	2
.0000	.0002	.0577	6.0	.0206	1.4600	–	–	.0840	1.6800	1.1456	2.6120	156	3

Charlestown Group.

Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.	Silica.	Alumina.	Oxide of Manganese.	Alumina and Oxide of Manganese.*	Lime.	Magnesia.	Sulphuric Acid in combination with Lime.	Depth of Well. Feet.	
.0000	.0002	.4836	163.0	1.0286	2.3600	.3733	.6830	–	17.1660	96.8700	25.8200	185	4
.0000	.0000	.4312	169.0	.5143	–	–	–	–	–	–	–	185	5
.0000	.0003	.3159	104.0	.1414	2.2900	.0800	.3166	–	8.6600	33.6300	9.5150	200	6
.0000	.0003	.1809	102.0	.0771	–	–	–	–	–	–	–	200	7
.5000	.0100	.0507	34.0	.0256	1.5160	–	–	.0980	8.8700	3.4300	6.9720	350	8
.0000	.0030	.2106	90.0	.0385	1.7230	–	–	.6900	7.8000	24.8300	11.4600	365	9
.0000	.0010	.1232	92.5	.0373	–	–	–	–	–	–	–	365	10

Boston, South End, Group.

Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.	Silica.	Alumina.	Oxide of Manganese.	Alumina and Oxide of Manganese.*	Lime.	Magnesia.	Sulphuric Acid in combination with Lime.	Depth of Well. Feet.	
.0000	.0000	.1755	49.0	.0222	1.2500	.1143	.0833	–	8.5830	10.0000	10.3800	80	11
.0030	.0000	.1809	16.4	.0256	–	–	–	–	–	–	–	80	12
1.1000	.0004	.0702	26.0	.0026	1.5450	.0572	.0000	–	9.0250	4.3080	5.6860	100	13
.0000	.0000	.1513	16.0	.0219	1.5670	–	–	.0757	3.7700	3.4530	9.2635	120	14
.0000	.0000	.3120	19.4	.6943	1.9550	–	–	1.1386	4.2800	4.0390	1.2360	126	15
.0000	.0001	.4812	26.0	.0900	1.5630	–	–	.1600	8.2530	5.6876	10.9460	140	16
.0030	.0000	.1209	6.6	.0463	1.1660	–	–	–	1.9800	1.4260	4.4858	152	17

Boston, Back Bay.

Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.	Silica.	Alumina.	Oxide of Manganese.	Alumina and Oxide of Manganese.*	Lime.	Magnesia.	Sulphuric Acid in combination with Lime.	Depth of Well. Feet.	
.0000	.0000	.3393	18.0	.0385	1.1300	–	–	.0905	5.5400	4.5630	11.8420	135	18

* In those analyses in which the manganese was not determined directly it has been included with the alumina, but in none of these cases was there any considerable amount of oxide of manganese.

CHEMICAL EXAMINATION OF WATER FROM

Boston Proper Group.

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.	Ammonia.		Chlorine.
			Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Albuminoid.	
		1894.									
1	12292	June 1	Slight, milky.	Slight.	0.10	Faintly tarry.	None.	55.50	.0074	.0006	12.92
2	12291	June 1	Decided, milky.	Slight.	0.00	Faint of sulphuretted hydrogen.	Faintly tarry.	75.60	.2000	.0020	16.39
3	12293	June 1	Decided, milky.	Cons., rusty.	0.70	Faint or none.	Distinct.	80.50	.0234	.0032	12.64
4	12259	May 21	Decided, milky.	Cons., rusty.	0.20	Distinctly disagree'ble, like marsh gas.	Faint or none.	40.60	.0120	.0004	12.80

South Boston Group.

5	12818	Aug. 24	Decided.	Slight, earthy.	0.00	V. faint.	None.	92.90	.2880	.0092	19.60
6	12817	Aug. 24	Slight.	Slight.	0.00	None.	None.	49.50	.0000	.0024	8.40
7	12816	Aug. 24	Slight.	Slight.	0.02	None.	None.	67.00	.0008	.0008	21.16
8	12656	Aug. 6	None.	None.	0.04	None.	Faint.	158.80	.0000	.0034	44.00
9	12657	Aug. 6	Distinct, milky.	Slight, earthy, rusty.	0.00	Sulphuretted hydrogen.	None.	17.80	.0048	.0000	4.80

DEEP WELLS IN BOSTON AND VICINITY — Concluded.

Boston Proper Group.

[Parts per 100,000.]

Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.	Silica.	Alumina.	Oxide of Manganese.	Alumina and Oxide of Manganese.*	Lime.	Magnesia.	Sulphuric Acid in combination with Lime.	Depth of Well. Feet.	
.0000	.0003	.0231	21.0	.1646	3.5230	–	–	.5000	7.8000	5.0328	6.9767	200	1
.0000	.0001	.0631	34.0	.1736	1.5160	–	–	.2610	15.1260	4.8227	10.4034	205	2
.0000	.0003	.0924	39.0	.5014	2.0830	.1100	.2760	–	16.8030	5.5652	14.1124	213	3
.0000	.0000	.0764	5.0	.5014	3.4267	.2396	.0000	–	.9500	1.1860	1.9914	377	4

South Boston Group.

Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.	Silica.	Alumina.	Oxide of Manganese.	Alumina and Oxide of Manganese.*	Lime.	Magnesia.	Sulphuric Acid in combination with Lime.	Depth of Well. Feet.	
.0500	.0001	.1309	34.4	.1158	1.6767	.0400	.0000	–	5.9267	1.3763	2.4920	34	5
.0200	.0080	.0500	28.8	.0258	1.5567	–	–	.1033	6.2767	2.2833	3.2270	80	6
.0400	.0030	.0385	28.8	.0192	1.2300	–	–	.1010	12.5100	3.2252	3.8627	200	7
.1000	.0200	.1078	56.8	.0192	2.8000	–	–	.0850	19.8200	9.2900	12.8950	1200	8
.0000	.0000	.0154	11.4	.1285	1.3750	–	–	.0250	5.1500	1.8018	3.5770	1200	9

* In those analyses in which the manganese was not determined directly it has been included with the alumina, but in none of these cases was there any considerable amount of oxide of manganese.

ON THE

BACTERIAL CONTENTS OF CERTAIN GROUND WATERS,

INCLUDING

DEEP WELLS.

By W. T. SEDGWICK, Ph.D., Biologist of the Board, and S. C. PRESCOTT, S.B.

ON THE BACTERIAL CONTENTS OF CERTAIN GROUND WATERS, INCLUDING DEEP WELLS.

By W. T. Sedgwick, Ph.D., Biologist of the Board, and S. C. Prescott, S.B.

It is commonly held by bacteriologists that ground waters are comparatively free from bacteria, and that the waters of deep wells are nearly, if not quite, sterile. Sternberg, in his well-known "Manual," published in 1892, expresses the prevailing opinion when he remarks (page 553), "It is only in the water of springs and wells which come from the deeper strata of the soil that they [bacteria] are absent." Still more recently Abbott ("Principles of Bacteriology," 1894, page 479) affirms that "all waters except deep ground water contain bacteria." The Franklands ("Micro-organisms in Water," 1894, page 107) are, however, much more guarded, when, after quoting various results, they state "all these investigations show what a high degree of bacterial purity is possessed by these deep wells; and, when the enormous depths of porous strata are taken into consideration through which the water gaining access to such wells has to pass, this poverty in microbial life is not to be wondered at."

In the earlier bacteriological work of the State Board of Health of Massachusetts similar views were held by those engaged in actual analysis; but more recently, with enlarged experience and improved technic, doubt has been thrown upon the validity of the principle that ground waters are normally free, or nearly free, from bacteria. We have therefore made a careful and somewhat extended re-examination of the subject, using the most modern methods and appliances; and from our results are forced to the conclusion that ground waters, even the waters of deep wells, may not be by any means as free from bacteria as has been hitherto supposed.

We have used the ordinary methods, but have paid special attention to the nutrient gelatin employed, in respect to its composition, acidity and sterilization. The experiments were carried on chiefly

during the winter months, when the liability to contamination was least, owing to the cold and the fact that the ground was frozen.

As far as possible the determinations were made immediately after collection of the specimen, thus avoiding any chance for multiplication before the sample was planted. In a majority of cases several different varieties of gelatin or other media have been used in the quantitative determinations, thus affording special controls in addition to the usual blank determinations, and in almost all cases duplicate or triplicate determinations were made with the medium chiefly relied on. The period of incubation was in general from three to five days, or even longer; and the temperature of incubation 20° to 22° C.

For convenience we may divide the ground waters into two classes, namely, first, springs and open wells; and, second, "tubular" wells. We have done this because the ordinary springs and open wells form a group by themselves in respect to the possibility of aerial and surface contamination; while the tubular wells, whether shallow or deep, are much less exposed in this respect.

Bacteria in Springs and Open Wells.

Under this heading we have examined not only springs, as they occur in the vicinity of cities or regions of considerably crowded population, but also those found in sparsely settled neighborhoods and under conditions as nearly "normal" as possible, that is, not in any way exposed to house drainage or sewage of any kind.

A series of springs situated in a country district of southern New Hampshire was first selected for examination. The samples were all planted on the day of collection. External conditions were quite favorable, as the ground was frozen, and covered with six inches of snow. No rain had fallen for several days, thus reducing the liability to contamination from surface water to a minimum.

Open Spring No. 1. — Situated in a field on edge of meadow. Water comes up through a stratum of clay. Rate, several barrels per hour. Water clear and colorless. Date of analysis, Nov. 29, 1894. Bacteria per cubic centimeter, on gelatin, 252, 258; on glycerin agar, 143, 167.

Open Spring No. 2. — About 500 feet from No. 1. Conditions nearly the same, but the bottom of the spring is covered with a layer of fine sediment. Algæ, etc., grow in the water. Date of analysis, Nov. 29, 1894. Bacteria per cubic centimeter, gelatin, 163, 134; glycerin agar, 133, 133.

Open Spring No. 3. — Situated in meadow at base of a wooded hill 400 feet high. No habitation within one-half mile. Other conditions similar to those in No. 2. Date of analysis, Nov. 29, 1894. Bacteria per cubic centimeter, gelatin, 92, 105; glycerin agar, 72, 79.

Open Spring No. 4. — Situated on southern slope of hill mentioned in description of No. 3, about 150 feet below the summit, in wooded region. Oak, birch and pine trees all around. No cultivated land above. Soil gravelly. Date of analysis, Nov. 29, 1894. Bacteria per cubic centimeter, gelatin, 95, 106; glycerin agar, 89, 96.

Open Spring No. 5. — Open land, near top of a hill used in summer for pasture. Soil gravelly. Date of analysis, Nov. 29, 1894. Bacteria per cubic centimeter, gelatin, 193, 218; glycerin agar, 203, 217.

Open Spring No. 6. — Low land (pasture), surrounded by shrubs and trees. No buildings anywhere near. Date of analysis, Nov. 29, 1894. Bacteria per cubic centimeter, gelatin, 100, 43; glycerin agar, 72, 36.

A series of wells was next examined. These were mostly of a depth varying from 15 to 40 feet, and the source of water was almost certainly a ground supply. Here the chances for contamination were also slight, but not absent.

Open Well No. 1. — Close to roadside. Sandy soil. Depth about 15 feet. Operates by bucket. Buildings 5 rods away. Date of analysis, Nov. 29, 1894. Bacteria per cubic centimeter, gelatin, 509, 525; glycerin agar, 204, 228.

Open Well No. 2. — On hill top. Sandy soil. Depth about 30 feet. Operates by bucket. House 2 rods away. Date of analysis, Jan. 2, 1895. Bacteria per cubic centimeter, gelatin, 248, 190; glycerin agar, 140.

Open Well No. 3. — Near house. Conditions not so favorable. Depth 15 feet. Bacteria per cubic centimeter, gelatin, 602, 560; glycerin agar, 469.

Open Well No. 4. — On hill top. Near house, but yet favorably situated. Soil sandy and gravelly. Date of analysis, Jan. 2, 1895. Bacteria per cubic centimeter, gelatin, 335, 332; glycerin agar, 229.

Open spring No. 6 was again examined about five weeks after the first analysis (Jan. 2, 1895). The result was as follows: gelatin, 201, 216; glycerin agar, 120 bacteria, per cubic centimeter.

Four wells of unknown depth were also tested for bacteria. Of these, three were in Hyde Park and one was in Arlington. Results (on gelatin) per cubic centimeter, Oct. 27, 1894: —

Hyde Park, No. 1,	2,084	2,064	2,247
Hyde Park, No. 2,	8,905	8,905	8,640
Hyde Park, No. 3,	702	910	871
Arlington,	720	712	763

Two samples of a spring water of great chemical purity, sold in Boston, and taken from a freshly opened carboy, yielded on analysis the following results: sample No. 1, gelatin, 223, 261; glycerin agar, 207, 197 bacteria, per cubic centimeter; sample No. 2 (one day later), gelatin, 165, 157; glycerin agar, 166, 157 bacteria, per cubic centimeter.

A spring water (so called, though it was pumped through a pipe) from Lowell gave on analysis these results: gelatin, 229, 252 bacteria per cubic centimeter; glycerin agar, 246, 235 bacteria per cubic centimeter. A few days later samples of the same "spring" were again taken, and yielded on analysis with gelatin, 625, 658 bacteria per cubic centimeter; with glycerin agar, 558, 527 per cubic centimeter. This spring (or well) is situated remote from any habitation, but in a field near cultivated land. The water is sold in Lowell as a "spring water," and from the chemical point of view is well purified.

The foregoing results, taken together with those of other observers, suffice to show that open springs and wells, even when wholly unpolluted and "normal," may contain larger numbers of bacteria than some surface waters, such as many lakes and slow streams.

Bacteria in Tubular Wells.

In the foregoing pages the bacterial contents of comparatively pure springs and open wells only have been recorded. It now remains to consider another great division of ground waters, namely, those derived from "tubular" wells, *i. e.*, wells of relatively great depth and small diameter in which (ground) water is delivered at the surface from a pipe sunk more or less deeply into the earth. Such a well, if carefully constructed, should ordinarily be perfectly free from all surface-water contamination.

From this brief statement of the nature of tubular wells it will be seen that contamination from air, or from surface water, as such, should be, ordinarily, and except in case of fissures, impossible. Any contamination must, it would seem, be the result of infiltration through a layer of soil of considerable depth, and in this case the contaminating fluid is no longer a surface water, but a ground water of more or less purity, according to the completeness of the filtration.

It is, however, possible that bacteria originally present, for any reason, inside the driven pipe, or their descendants, continue to live in moderate numbers within the pipe and thus render the water richer in bacteria than it would otherwise have been. And, again, it must be regarded as a possibility that cracks or other openings may be made in the pipe by "driving;" or that in some methods of construction, or under certain peculiar conditions, a space may remain, outside the tube, filled with water derived from a point comparatively near the surface but passing down and into the pipe when the pumps are worked.

Since all true ground waters are really filtered surface waters, any bacteria which they contain must come from bacteria living in the earth, or from the original surface water, or from the multiplication of bacteria derived from one or both of these sources, or else from some such sources as those indicated in the last paragraph. All that we have undertaken to prove is that such waters, drawn with all possible precautions, do contain considerable numbers of bacteria.

Bacteria in Deep Tubular Wells.

In collecting samples of water from deep wells for bacteriological analysis several conditions have been carefully sought after, and, in general, fulfilled. The samples have always been taken when the pumps were actively working, and, with two exceptions, after several hours of continuous pumping. Two of the samples were taken after the pump had been working but a few minutes.

The samples have always been collected at the point of outflow nearest the well. In many cases this was effected by a petcock on the pump, or a tap very near the pump. In a few cases the samples were taken as the water flowed out from the pipe into a tank, but before it reached the tank.

We may now record the various results of the examinations: —

No. 1. — A sample from a driven well in Cambridge, depth, 193 feet, in rather gravelly soil, gave on analysis (in duplicate) 269 and 254 bacteria per cubic centimeter. The gelatin plates by means of which these determinations were made showed no sign of liquefaction, even six days after the sample had been planted. (This fact has been repeatedly noticed in connection with the water of deep wells.)

No. 2. — A sample from a well used for a private supply, and operated by a hand pump, gave 30 bacteria per cubic centimeter. In this case the sample was taken after several minutes of continuous pumping. The depth of this well is about 100 feet, and the soil sandy and more compact than in the previous case.

Two other wells have been studied, both in the same locality, and the samples were taken under the same conditions. Pumps at both wells had been working steadily for several hours.

No. 3. — Depth, 454 feet. Bacteria per cubic centimeter, 206, 214.

No. 4. — Depth, 254 feet. Bacteria per cubic centimeter, 150, 135.

No. 5. — Driven wells at Lowell; part of the city supply. (Petcock on pump, Dec. 21, 1894.) Bacterial analysis gave, with gelatin, 228 bacteria per cubic centimeter; with glycerin agar, 178. The chemical analysis of this water was the following: —

[Parts per 100,000.]

Appearance.			Odor.		Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Albuminoid.		Nitrates.	Nitrites.			
None.	V. slight.	0.04	None.	None.	8.00	.0004	.0034	.60	.0300	.0003	.0308	3.5	.0100

No. 6. — Cambridgeport. Driven well; depth, 198 feet; diameter, 8 inches. In thickly settled, level region, not more than 500 yards from Charles River estuary. Various samples from this well have been tested. Samples taken from pipe leading to tank. (*a*) Bacteria per cubic centimeter, 116; (*b*) bacteria per cubic centimeter, 192, 193; (*c*) bacteria per cubic centimeter, 262, 258.

No. 7. — Well on Chardon Street, in the city of Boston. Depth of well, 213 feet. Bacteria per cubic centimeter, 138, 139, 140, 130. Sample taken as water flows into tank on roof, direct from pump.

Chemical Analysis.

[Parts per 100,000.]

Appearance.			Odor.		Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.
Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Albuminoid.		Nitrates.	Nitrites.			
Decided.	Slight.	0.00	Faint of sulphuretted hydrogen.	Faintly tarry.	75.60	.2000	.0020	16.39	.0000	.0001	.0631	34.0	.1736

No. 8. — Well on Hawkins Street, Boston, near the preceding. Depth, 213 feet. Sample taken as water flows into tank on roof. Bacteria per cubic centimeter, 101, 106. Another sample, some days later, gave 408, 400, 416 bacteria per cubic centimeter.

Chemical Analysis.

[Parts per 100,000.]

Appearance.			Odor.		Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.
Turbidity.	Sediment.	Color.	Cold.	Hot.		Free.	Albuminoid		Nitrates.	Nitrites.			
Decided.	Cons., rusty.	0.70	Faint or none.	Distinct, sweet.	80.50	.0234	.0032	12.64	.0000	.0003	.0924	39.0	.5014

No. 9. — Well on Fort Hill Square, in the city of Boston. Depth of well, 377 feet. Sample taken from petcock on pump. Bacteria per cubic centimeter, 48, 54. Another (later) sample gave, on examination, bacteria per cubic centimeter, 158, 149.

Chemical Analysis.

[Parts per 100,000.]

Appearance.			Odor.		Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Oxide of Iron, FeO.
Turbidity.	Sediment.	Color.	Cold.	Hot		Free.	Albuminoid.		Nitrates.	Nitrites.			
Decided, milky.	Cons., rusty.	0.20	Distinctly disagreeable, like marsh gas.	Faint or none.	40.60	.0120	.0004	12.80	.0000	.0000	.0764	5.0	.5014

No. 10. — Wells on Third Street, Cambridgeport. Depth, 227 feet. Bacteria per cubic centimeter, 1,240, 1,376. Another sample, about a week later, gave per cubic centimeter, 486 bacteria. Chemical analysis not obtained.

No. 11. — Well in Back Bay district of Boston. Depth, 130 feet. Sample taken from petcock on pump. Bacteria per cubic centimeter, 440, 480. Chemical analysis not obtained.

No. 12. — Well on Second Street, South Boston. Depth, 200 feet. From description of engineer it appears that while the pipe extends only to a depth of a little more than 200 feet, the well was originally bored to a depth of over 1,200 feet. Bacteria per cubic centimeter, 525.

Without giving a detailed account, we may simply state results obtained from other deep wells: —

Place.	Depth.	Bacteria per Cubic Centimeter. (Gelatin.)
Roxbury,	180 feet.	60, 57
Somerville,	67 "	165
Roxbury,	750 "	38

It is difficult to find deep wells in uninhabited or "country" districts, and our results are all derived from populous areas. It is possible that other results might be obtained from wells driven in uninhabited regions.

It is plain, however, that water absolutely free from bacteria is not ordinarily obtained from even deep wells, and that many deep wells contain as numerous bacteria as are found in many surface waters.

The reasons why these facts have not before been well known have already been suggested. In the first place, we have had the advantage of improved technic, and, especially, a most favorable set of culture media, carefully prepared in respect to composition and acidity. Secondly, we have made use of an increased period of incubation. In several cases with deep-well waters we have had no growth whatever until the third day, and in such cases the numbers did not usually cease to grow larger until the fifth day

of incubation, or even later. But this slow growth was not always a feature of the bacteria of deep wells.

Much attention has been given to the probable source of the bacteria in ground waters and to the species present; but a report on these parts of the investigation must be reserved for another paper. It may be here stated, however, that the plates are remarkable not only for the slow growth of the species present but, also, for the absence of liquefying colonies, and, in many cases, for the abundance of chromogenic varieties. These facts are especially important, as indicating the total absence of contamination by ordinary surface water, and, as far as they go, they strengthen the confidence with which well-protected ground waters may be regarded as sources of public water supplies.

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

DURING THE YEAR 1894.

EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AND WATER AT THE LAWRENCE EXPERIMENT STATION.*

By GEORGE W. FULLER, Biologist in Charge.

The year 1894 is the seventh that the investigations of the Lawrence Experiment Station have been continued. The work has been carried on under the general supervision of Hiram F. Mills, A.M., C.E., a member of the State Board of Health, with the writer in direct charge. Mr. Harry W. Clark has been in charge of the chemical department, and Mr. F. L. Fales has compiled the records and prepared the tables showing the results of the work. Messrs. W. R. Copeland and Louis Weinberg have been assistant biologists, and Mr. F. B. Forbes assistant chemist. Professors T. M. Drown and W. T. Sedgwick of the Massachusetts Institute of Technology have been, respectively, consulting chemist and biologist, having a general oversight of the chemical and biological investigations.

The chief features of the present report upon the purification of sewage are: the investigations upon the composition of sewage; the influence of the composition of sewage and of temperature upon nitrification; the permanency and efficiency of sewage filters, with a summary of seven years' work; the management of sewage filters to secure continuous efficiency; the effect upon filtration of sewage of winter weather in Massachusetts; and results of experiments upon the rapid filtration of sewage from which sludge has been removed by different methods.

With regard to water filtration, a prominent point is the result of studies upon coarser filters operated at higher rates of filtration, together with a detailed account of the influence upon bacterial

* A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a special report of the State Board of Health upon the Purification of Sewage and Water, 1890. A similar account for the years 1890 and 1891 is contained in the twenty-third annual report of the Board for the year 1891. Since 1891 the results have been published yearly in the annual reports.

efficiency of the various treatments met with in actual practice, and an outline of the operation of the Lawrence city filter with the results of numerous chemical and bacterial analyses.

Following this is a paper by Mr. Clark upon the physical and chemical properties of sand with reference to their use in filtration. The account of the work of the station closes with a series of papers in which are described some of the improved bacterial methods now in use in the Lawrence laboratory.

Filtration of Sewage.

Attention has been repeatedly drawn to the fact that sewage varies widely in its composition, and that when subjected to filtration different sewages require different amounts of air and different periods of time for the bacteria to effect thorough purification. The question of the composition of sewage has, accordingly, received special study during the past year.

Investigation upon the Composition of Sewage, together with Results of Analyses of Sewage applied to Experimental Filters.

The sewage used at the experiment station is pumped through a 2.5 inch pipe, 4,300 feet long, from a sewer which drains the streets, houses and stores of the most densely populated sections of the city of Lawrence. Over the end of this pipe is a cap, and the sewage enters through a series of perforations about three-quarters of an inch in diameter; these perforations are freed from paper and other clogging matter once a week, and the entire pipe is flushed out with city water under pressure, several times each year, as occasion requires.

Weekly samples have been collected on Saturdays, of the sewage from the man-hole where this pipe begins. This man-hole is on Lawrence Street, just below Essex Street, which is the chief business thoroughfare of the city, and above the entrance of the wastes from the large mills.

The samples, which have been analyzed with the results in the following table, were collected about 8.30 A.M. On page 477 will be found monthly averages of chemical analyses of daily samples of sewage collected at this man-hole at about 1 P.M., beginning in June.

Monthly Averages of Analyses of Sewage from the Lawrence Street Sewer.

[Parts per 100,000.]

1894.	Temperature. Deg. F.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.*	Bacteria per Cubic Centimeter.
			Total.	Soluble.	Insoluble.		Nitrates.	Nitrites.		
January,	45	3.25	1.15	.63	.52	7.35	-	-	4.70	896,000
February,	45	2.15	.91	.54	.37	6.10	.0100	.0006	4.70	680,000
March,	46	2.02	1.34	.94	.40	7.62	.0200	.0000	9.55	609,000
April,	49	2.62	.91	.51	.40	8.33	.1200	.0140	3.95	1,119,000
May,	53	2.40	.75	.51	.24	9.26	.1700	.0150	3.95	787,000
June,	59	2.76	.91	.51	.40	9.51	.1000	.0140	4.40	846,000
July,	68	3.14	1.04	.51	.53	9.57	.0500	.0120	5.85	1,852,000
August,	69	2.96	1.03	.53	.50	11.45	.0800	.0190	5.15	1,902,000
September,	66	3.06	1.05	.65	.40	11.07	.1000	.0104	5.28	2,490,000
October,	62	3.81	.86	.64	.22	8.31	.0700	.0120	5.12	2,260,000
November,	50	3.05	.99	.67	.32	8.67	.1300	.0120	7.92	2,217,000
December,	51	2.90	1.12	.72	.40	8.94	.1100	.0104	6.54	2,217,000
Averages,	55	2.84	1.00	.61	.39	8.85	.0900	.0109	5.59	1,490,000

* In all of the Lawrence analyses the oxygen consumed has been determined after boiling two minutes, unless otherwise stated.

It will be seen, upon comparing these results with those in subsequent tables, that these sewage samples contained a larger quantity of albuminoid ammonia than those of sewage which has been applied to the filters. This is largely owing to the fact that the average sewage for the day is more dilute than that collected at this particular hour. This point is shown by the table of analyses of hourly samples taken in January, 1894, and presented in the last annual report, page 407, and also by the following series of analyses of samples collected in August.

Results of Analyses of Hourly Samples of Sewage from the Lawrence Street Sewer.

[Parts per 100,000.]

Date — 1894.	Hour.	Estimated Rate of Flow. — Gallons per 24 Hours.	Temperature. Degrees F.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Organic Nitrogen by Kjeldahl Method.	Total Nitrogen. — Organic Nitrogen by Kjeldahl Method.	Oxygen Consumed.		Per Cent. of Dissolved Oxygen.	Hardness.	Fats.	Bacteria per Cubic Centimeter.
					Total.	Soluble.	Insoluble.		Nitrates.	Nitrites.			2 Minutes.*	5 Minutes.*				
August 15, . . .	7 P.M.	795,000	68	1.50	.40	.29	.11	5.60	.11	.0000	1.70	3.05	2.20	2.80	45	16.8	.5	980,000
" 15, . . .	8 "	795,000	68	1.55	.46	.31	.15	5.29	.15	.0000	1.76	3.18	2.20	2.80	46	18.6	1.7	930,000
" 15, . . .	9 "	581,700	64	1.50	.37	.27	.10	4.87	.08	.0000	1.62	2.94	1.90	2.60	40	19.0	.0	700,000
" 15, . . .	10 "	620,500	64	1.75	.30	.23	.07	6.11	.17	.0000	1.76	3.37	1.70	2.30	32	14.0	.0	850,000
" 15, . . .	11 "	723,900	63	1.55	.23	.16	.07	4.48	.20	.0000	1.00	2.48	1.20	2.20	43	16.2	.6	880,000
" 15, . . .	12 "	665,300	63	1.00	.17	.09	.08	4.02	.20	.0000	.66	1.68	.90	1.80	45	13.8	.7	600,000
" 16, . . .	1 A.M.	517,000	62	.71	.12	.05	.07	3.45	.21	.0500	.44	1.23	.70	1.10	47	12.4	.0	470,000
" 16, . . .	2 "	549,400	63	.69	.09	.01	.08	3.20	.24	.0020	.36	1.17	.70	1.20	49	12.2	.5	450,000
" 16, . . .	3 "	517,000	62	.59	.10	.06	.04	3.08	.23	.0350	.40	1.15	1.00	1.70	51	11.8	1.3	330,000
" 16, . . .	4 "	581,700	62	.50	.06	.04	.02	2.91	.25	.0190	.38	1.05	.50	.90	53	11.0	.6	260,000
" 16, . . .	5 "	581,700	62	.54	.08	.05	.03	2.82	.29	.0240	.46	1.21	.70	1.20	55	10.6	.5	300,000
" 16, . . .	6 "	794,900	62	2.20	.60	.35	.25	4.89	.22	.0000	1.96	3.99	2.50	3.10	39	20.8	.7	1,100,000
" 16, . . .	7 "	1,021,000	64	3.50	.82	.49	.33	6.32	.18	.0000	3.46	6.52	3.70	4.90	32	26.0	1.0	1,300,000
" 16, . . .	8 "	1,196,000	64	3.95	1.15	.70	.45	19.45	.17	.0000	3.32	6.74	4.00	5.00	30	27.8	2.9	1,400,000
" 16, . . .	9 "	1,357,000	65	3.20	.83	.47	.36	6.82	.15	.0000	3.12	5.81	5.60	6.80	14	31.0	2.6	1,960,000
" 16, . . .	10 "	1,060,000	65	2.40	.69	.41	.28	8.78	.12	.0000	2.28	4.38	4.20	5.60	34	25.0	3.8	2,000,000
" 16, . . .	11 "	1,029,000	65	2.05	.67	.39	.28	7.65	.15	.0000	2.16	3.99	4.30	6.50	33	22.0	8.3	2,220,000
" 16, . . .	12 "	1,196,000	67	1.60	.68	.32	.36	7.55	.20	.0000	1.64	3.16	4.30	5.20	36	18.0	1.7	1,200,000
" 16, . . .	1 P.M.	956,500	67	1.80	.65	.34	.31	7.68	.17	.0000	2.22	3.87	3.40	5.40	33	18.0	1.1	1,300,000
" 16, . . .	2 "	1,196,000	65	1.80	.76	.42	.34	6.72	.15	.0000	2.18	3.81	4.80	6.40	35	18.4	12.6	1,100,000
" 16, . . .	3 "	1,196,000	66	1.40	.58	.33	.25	7.04	.06	.0000	1.80	3.01	3.70	6.30	33	15.6	11.4	1,350,000
" 16, . . .	4 "	1,661,000	66	1.25	.57	.33	.24	7.01	.15	.0000	1.63	2.82	8.10	9.70	34	13.0	1.6	1,250,000
" 16, . . .	5 "	1,583,000	66	1.30	.45	.28	.17	5.12	.15	.0000	1.61	2.83	3.50	4.50	34	16.2	1.6	1,100,000
" 16, . . .	6 "	1,196,000	67	1.00	.33	.29	.04	4.03	.12	.0000	1.19	2.13	2.00	2.90	40	13.8	.3	930,000

* Time of boiling.

In addition to the marked variations during the day in the composition of the sewage, and to the presence of nitrates, attention is specially called to the uniform presence of dissolved oxygen in the fresh sewage of the sewer, as was pointed out in the last Report. Dissolved oxygen in this sewage has been uniformly found in quantities ranging from 10 to 60 per cent. of that necessary to saturate water at the temperature when collected. After a few hours, varying with the temperature and other conditions affecting bacterial action, this oxygen disappears. But before discussing the changes in the composition of sewage, results of numerous analyses of the sewage pumped at the station and applied to the experimental filters will be presented.

Analyses of Samples of Sewage applied to the Experimental Filters.

Samples of sewage after it has been pumped through the pipe, 4,300 feet in length, have been regularly collected for analyses as follows: —

1. *Regular Sewage.* — On at least four days in a week a gallon bottle has been filled from a large tank of sewage. While the sample was intended to be as far as possible a representative one, it necessarily represented accurately only a small fraction of the total amount of sewage used; and there is also considerable difficulty in mixing several hundred gallons of sewage so as to get a sample with its proper share of suspended matter.

2. *Average Sewage.* — On one day each week (Tuesday) a sample has been taken by collecting directly from the pump (without allowing any opportunity for sedimentation) quantities of sewage proportional to the amount of each lot of sewage pumped during the day. The average results from numerous samples collected in this manner indicate satisfactorily the average composition of all sewage applied to the filters.

3. *Sewage for Filters Nos. 1, 6 and 9 A.* — In order to learn the variations in strength of sewage at different times of the day, and to obtain more accurate data upon the storage of organic matter in the filters, there have been collected weekly three mixed samples, representing each dose applied during the week to Filters Nos. 1, 6 and 9 A, respectively. In order to keep the samples for one week without putrefaction and decomposition, a small amount of mercuric acetate has been placed in the bottle at the beginning of the week. When this compound has been used in the proportion of 1 part to

4,000 it has been found to sterilize effectually the sewage. It unites with the organic matter, however, causing more or less precipitation, so that the determination of relative amounts of soluble and suspended organic matters is practically valueless.

Monthly Averages of Analyses of Regular Sewage Samples.

[Parts per 100,000.]

1894.	Temperature. Deg. F.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Albuminoid Ammonia. Insoluble.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	38	2.79	.67	.30	.37	6.39	4.06	736,400
February,	35	2.33	.51	.25	.26	5.25	3.22	547,200
March,	40	2.25	.53	.26	.27	5.09	3.01	549,900
April,	48	3.16	.77	.28	.49	7.71	3.98	1,222,200
May,	59	4.62	.62	.30	.32	8.71	2.65	1,050,000
June,	65	3.33	.50	.20	.30	8.47	2.35	867,000
July,	75	3.10	.54	.22	.32	9.74	2.82	1,444,400
August,	71	3.60	.61	.20	.41	10.70	3.26	1,788,000
September,	66	3.74	.56	.20	.36	9.46	3.68	1,745,000
October,	55	4.10	.64	.31	.33	9.10	3.50	1,941,000
November,	43	4.26	.70	.29	.41	8.07	4.65	1,995,000
December,	39	3.90	.87	.29	.58	8.11	5.31	2,072,500
Averages,	53	3.43	.63	.26	.37	8.07	3.54	1,329,900

The above analyses represent four samples each week taken from the sewage tanks, usually in the morning, and the results are directly comparable with the analyses published for previous years.

Monthly Averages of Analyses of Average Sewage Samples.

[Parts per 100,000.]

1894.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Albuminoid Ammonia. Insoluble.	Chlorine.	Oxygen Consumed.	Fats.
January,	2.83	.76	.41	.35	6.43	4.58	5.0
February,	3.05	.60	.34	.26	5.90	4.22	4.6
March,	2.80	.58	.32	.26	5.31	3.92	3.6
April,	3.49	.69	.35	.34	7.26	3.81	4.6
May,	3.77	.59	.30	.29	8.31	2.70	5.3
June,	3.18	.55	.20	.35	8.58	2.63	3.7
July,	3.44	.55	.21	.34	9.92	3.76	4.5
August,	4.84	.76	.32	.44	10.98	3.82	4.7
September,	4.71	.86	.30	.56	10.99	4.37	1.7
October,	4.85	.87	.36	.51	10.76	3.98	4.0
November,	4.64	.70	.35	.35	7.55	4.02	3.2
December,	4.61	.90	.42	.48	10.12	5.27	8.2
Averages,	3.85	.70	.32	.38	8.51	3.92	4.4

The above analyses represent average samples of all the sewage pumped during the day for each Tuesday of the year.

Monthly Averages of Mixed Samples, representing all of the Sewage applied to Filters Nos. 1, 6 and 9 A.

[Parts per 100,000.]

1894.	Free Ammonia.			Albuminoid Ammonia.			Oxygen Consumed.			Chlorine.		
	Filter No. 1.	Filter No. 6.	Filter No. 9 A.	Filter No. 1.	Filter No. 6.	Filter No. 9 A.	Filter No. 1.	Filter No. 6.	Filter No. 9 A.	Filter No. 1.	Filter No. 6.	Filter No. 9 A.
January,	3.65	3.47	3.95	.84	.74	.91	4.77	3.80	4.70	7.73	7.58	7.56
February,	3.45	2.79	3.22	.75	.73	.63	5.17	3.55	3.90	6.49	6.57	5.85
March,	2.81	2.27	2.94	.71	.53	.64	4.08	2.80	3.62	7.06	5.80	6.42
April,	3.60	3.54	3.56	.60	.61	.70	3.70	3.30	3.42	7.30	6.63	6.80
May,	3.71	3.98	3.26	.55	.62	.43	2.97	3.08	2.18	8.72	9.46	7.73
June,	3.09	3.74	3.42	.45	.58	.50	2.46	3.32	2.52	9.06	10.89	9.83
July,	3.16	3.21	3.28	.84	1.07	.53	4.15	4.48	3.07	11.17	14.89	12.19
August,	3.65	3.92	3.76	.64	.66	.65	3.57	3.60	3.57	13.55	13.65	11.34
September,	3.97	3.89	4.13	.74	.70	.84	4.10	4.22	4.54	9.27	10.15	7.54
October,	4.52	4.38	4.82	.80	.82	.86	4.40	3.40	4.50	8.82	8.08	8.81
November,*	–	–	–	–	–	–	–	–	–	–	–	–
December,	4.50	5.05	3.95	.97	1.11	.76	4.82	6.32	4.50	7.50	7.74	9.16
Averages,	3.65	3.66	3.66	.72	.74	.68	4.02	3.81	3.68	8.79	9.22	8.48

* Filters Nos. 1, 6 and 9 A were rested in November.

With regard to the comparison of results with each other, there is this to be mentioned, that the sewage for Filter No. 1 was all pumped late in the afternoon during the cold weather, January to April inclusive; and during the rest of the year, excepting the last week in December, it was pumped one-half in the early morning and one-half in the afternoon. Sewage for Filter No. 6 was regularly pumped in the middle of the day. In the case of Filter No. 9 A the sewage was pumped late in the afternoon, January to April inclusive, and during the last week in December; while for the remainder of the year it was pumped in the early morning. These results are fairly comparable with corresponding results of previous years.

Monthly Averages of Analyses of Supernatant Liquid from Sewage treated with Sulphate of Alumina, for Filters Nos. 19 and 32.

[Parts per 100,000.]

1894.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Fats.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble				
January,	2.92	.27	.21	.06	5.50	2.40	.4	97,700
February,	2.31	.22	.14	.08	4.81	1.62	1.2	105,500
March,	2.09	.19	.15	.04	5.28	1.27	.9	69,300
April,	3.05	.26	.18	.08	7.28	1.72	.4	169,700
May,	4.57	.33	.27	.06	8.86	1.23	2.0	393,000
June,	3.38	.23	.13	.10	9.49	1.13	.5	317,500
July,	3.03	.22	.13	.09	10.63	1.36	.4	558,000
August,	3.47	.27	.16	.11	8.83	1.57	.7	1,115,000
September,	4.29	.30	.17	.13	13.65	2.07	.6	944,000
October,	4.01	.31	.21	.10	10.91	1.94	.6	621,600
November,	4.62	.32	.22	.10	8.91	2.62	2.1	475,000
December,	3.50	.27	.21	.06	9.00	2.20	.5	271,000
Averages,	3.44	.26	.18	.08	8.60	1.76	.9	428,000

The above analyses represent the supernatant liquid after the sewage represented by the regular samples has been treated with sulphate of alumina in the proportion of 1,000 pounds to 1,000,000 gallons of sewage, and allowed to settle for four hours. Settling has taken place in barrels. The supernatant liquid has been removed from a faucet half-way between the top and bottom of the sewage, and after its removal each day the sludge has been drawn off through a faucet at the bottom. These results show that 59.5 per cent. of the organic matter (total albuminoid ammonia) and 67.8 per cent. of the number of bacteria in the sewage have been removed. The removal of organic matter has been greater than in 1893, but the bacterial removal has been less, owing, apparently, to a more persistent growth of bacteria during the warmer months of the year upon the organic matter accumulated upon the sides of the barrel. Considerable attention has been given to the removal of organic matter from the sides of the barrel, but it has been found to be difficult to free these surfaces from all bacterial food.

Monthly Averages of Analyses of Supernatant Liquid from Settled Sewage, for Filter No. 13 A.

[Parts per 100,000.]

1894.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Fats.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble.				
January,	2.87	.51	.33	.18	5.79	3.82	–	653,700
February,	2.47	.45	.25	.20	4.99	2.75	2.0	446,000
March,	2.02	.34	.21	.13	5.08	2.37	1.9	485,700
April,	3.06	.46	.30	.16	7.40	3.20	1.0	805,000
May,	4.57	.54	.34	.20	8.99	2.27	1.8	975,000
June,	3.30	.35	.21	.14	8.41	1.80	1.0	677,000
July,	3.04	.32	.19	.13	11.11	2.12	1.1	1,266,000
August,	3.29	.30	.18	.12	9.41	2.20	2.2	1,315,000
September,	4.40	.42	.24	.18	14.27	2.77	.4	1,807,000
October,	3.83	.42	.25	.17	10.59	2.62	1.1	1,622,000
November,	4.60	.63	.37	.26	9.08	3.80	1.1	1,789,000
December,	3.47	.53	.32	.21	9.22	4.00	5.2	1,788,000
Averages,	3.41	.44	.27	.17	8.70	2.81	1.7	1,135,800

The above analyses represent the supernatant liquid after the sewage represented by the regular samples has been allowed to settle in barrels for four hours, after the same manner as has been just described for chemically precipitated sewage. These results show a removal of 30 per cent. of the organic matter (total albuminoid ammonia) and 14.6 per cent. of the number of bacteria from the sewage by sedimentation.

Monthly Averages of Analyses of Sewage, strained through Coke, for Filter No. 14 A.

[Parts per 100,000.]

1894.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble.			
June,	3.13	.30	.17	.13	9.74	1.67	918,000
July,	3.02	.25	.16	.09	22.48	1.42	1,102,000
August,	3.37	.26	.18	.08	12.40	1.65	732,000
September,	3.25	.30	.14	.16	9.10	2.20	479,500
October,	4.31	.33	.24	.09	11.44	2.14	1,679,000
November,	4.11	.29	.26	.03	8.62	2.12	801,500
December,	3.91	.39	.29	.10	8.72	3.00	1,077,500
Averages,	3.59	.30	.20	.10	10.36	2.03	969,900

The above analyses, beginning June 1, represent the regular sewage after straining through a layer of coke, supported by a thin layer of fine gravel. The depth of coke has varied as follows: June

1 to October 18, 1.5 inches; October 19 to November 7, 6 inches; November 8 to December 31, 8 inches. These results show a removal of 52.4 per cent. of organic matter (total albuminoid ammonia) and 42.9 per cent. of the number of bacteria in the unstrained sewage.

Further reference is made to these results beyond.

Comparison of the Strength of Station Sewage.

Bringing together for comparison the average results of analyses of the several series of sewage samples, we have: —

[Parts per 100,000.]

1894.	Free. Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Total Nitrogen.†
		Total.	Soluble.	Insoluble.			
Regular, ...	3.43	.63	.26	.37	8.07	3.54	3.86
Average, ...	3.85	.70	.32	.38	8.51	3.92	4.30
For Filter No. 1, . . .	3.65	.72	.29*	.43	8.79	4.02	4.17
For Filter No. 6, . . .	3.66	.74	.30*	.44	9.22	3.81	4.22
For Filter No. 9 A, . .	3.66	.68	.28*	.40	8.48	3.68	4.11

* Estimated.

† Calculated as $\frac{14}{17}$ of the sum of the free ammonia plus twice the albuminoid ammonia.

This table shows that sewage applied to Filter No. 6, and representing the concentrated morning sewage of the sewer, has contained more chlorine, albuminoid ammonia and total nitrogen than the average sewage that has been applied to Filters Nos. 1 and 9 A, each of which has been stronger in these substances than the regular sewage. With regard to the oxygen consumed, the results have been less regular, but they also indicate the regular sewage to have been the most dilute of all, as was the case in earlier years.

Comparison of the Composition of the Station Sewage, by Years.

In the next table are given the annual averages of analyses of regular sewage for each year since these investigations were begun, together with the amount of sewage pumped and the annual local rainfall. The most striking feature of these results is the marked increase in the free ammonia and total nitrogen of the sewage. As all nitrogen of the station sewage is in an unnitrified state, and so far as our present knowledge of the process of purification by filtra-

tion goes we can best specify the capacity of filters for purification in units of unoxidized substances, we find that the sewage is gradually becoming stronger.

With regard to the 1894 results we find that the free ammonia, total nitrogen and bacteria have been higher than ever before; but the crude organic matter, indicated by the amount of albuminoid ammonia and oxygen consumed, has been somewhat less than the average for the entire period.

The sludge for 1894, as shown by the insoluble albuminoid ammonia, however, is seen to have been identical with the average results. It will also be noticed that the proportion of total nitrogen formed by free ammonia has largely increased.

Comparison, by Years, of the Composition of "Regular" Sewage obtained at the Experiment Station, with the Average Quantities pumped, and the Local Annual Rainfall.

[Parts per 100,000.]

Year.	Average Quantity of Sewage Filtered. — Gallons per Day.	Annual Rainfall. — Inches.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Albuminoid Ammonia. Insoluble.	Chlorine.	Oxygen Consumed.	Total Nitrogen.	Bacteria per Cubic Centimeter.
1888, ...	2,230	55.11	1.55	.69	.16	.53	5.19	–	2.40	1,000,000
1889, ...	3,410	47.64	1.84	.55	.29	.26	4.92	–	2.41	708,000
1890, ...	3,360	51.73	1.82	.69	.38	.31	5.45	3.25	2.62	1,085,000
1891, ...	2,730	40.00	2.22	.73	.34	.39	7.37	3.64	3.02	693,000
1892, ...	2,590	34.98	2.45	.75	.34	.41	8.33	4.22	3.24	809,000
1893, ...	2,850	41.96	2.68	.63	.31	.32	8.57	3.45	3.23	923,000
1894, ...	2,000	32.35	3.43	.63	.26	.37	8.07	3.54	3.85	1,329,900
Averages, . .	2,740	43.40	2.28	.67	.30	.37	6.84	3.62	2.97	935,000

In explaining the changes in the composition of station sewage there are three factors to be taken into consideration: first, and doubtless the most important, is the fact that a large number of water-closet connections have been made since 1889, while the area drained by the sewers remains practically the same; second, the quantity of sewage pumped, which determines in part what portion of the day's sewage is applied to the filters; and, third, the rainfall. Comparing the total nitrogen and the chlorine in the sewage of the last four years with those in the sewage of the first three years, it is seen that the low rainfall coincides with the stronger sewage. The

line is not sharply drawn for individual years, and this factor is much disguised by the first one mentioned. It may be added that in 1894 the analyses of the mixed average samples of sewage for Filters Nos. 1, 6 and 9 A, presented in the preceding table, showed that the chlorine reached its maximum in this year of minimum rainfall.

A factor equally important with the rainfall is the amount of sewage pumped. The pipe leading to the station from the sewer has a capacity of about 1,100 gallons. The sewage has been pumped between 7 A.M. and 5 P.M., and the pipe has remained over night full of day sewage. In the early forenoon the pumps have been worked most regularly, and the small daily quantity within these limits means that there has been a larger proportion of the strong morning sewage admitted to the pipe and applied to the filters. The reasons for the diminution in the quantity of sewage used are the discontinuance of the application of sewage to trenches in the field, and to the use of some of the large sewage tanks for water filters.

Relation of Free Dissolved Oxygen in Sewage to Increase in Free Ammonia.

The explanation of the increased ratio of free ammonia to albuminoid ammonia requires further consideration. When a water supply largely, and sometimes completely, saturated with dissolved oxygen leaves the city, it takes with it, as it enters the sewers, the refuse matters of the consumers. These substances are decomposed in the presence of free dissolved oxygen and the oxygen of such compounds as nitrates and nitrites by the bacteria, large numbers of which enter the sewers with polluting matters. That is to say, the crude organic matters represented by the albuminoid ammonia are changed to simpler forms, or to free ammonia. To be more explicit, the bacteria attack the carbon, and in the presence of free oxygen convert it to carbon dioxide. There are set free nitrogen and hydrogen, which unite to form ammonia, and this in turn unites with the carbon dioxide to form ammonium carbonate. It is this compound which yields the "free ammonia" upon distillation. Time is required for the bacteria to effect this process, the time varying with the numbers and kinds of bacteria and with the nature of the organic matter, but principally with the temperature.

Many of the bacteria in fresh sewage are capable of growing in the absence as well as in the presence of free oxygen, and are known according to Pasteur's classification as facultative anærobes. After the sewage becomes stale and the free oxygen all consumed, these particular bacteria continue to live and produce foul odors, a process generally spoken of as putrefaction. Experiments show that the ratio of bacteria in the Lawrence Street sewage, which grow in an atmosphere of hydrogen, to those which grow in the presence of the oxygen of the air, is 9 to 10.

Free Dissolved Oxygen in Sewage disappears and Free Ammonia increases during Passage to the Station.

To apply these principles to the case at hand, we may say, as was stated for the main part in earlier reports, that the sewage in the Lawrence Street sewer contains free dissolved oxygen, as well as oxygen in the form of nitrates and nitrites, and that it receives the greater part of its polluting matters only a few minutes before its arrival at the point of collection. The ratio of free ammonia to albuminoid ammonia is comparatively small at this stage, because the time required for bacteria to decompose the crude organic matter of the sewage is insufficient. Next, the sewage passes through the pipe 4,300 feet long leading to the station. The time required for this step, usually several hours, is sufficient for the bacteria present in the sewage with the free oxygen, together with those bacteria firmly established upon the sides of the pipe, to decompose some of the crude organic matter into free ammonia, and to partially effect the first step in the purification of sewage.

Modified Composition of Station Sewage in which there is no Free Dissolved Oxygen.

As the sewage is pumped at the station we find that there is no free oxygen present, nitrates and nitrites are absent, and when compared with the sewage in the sewer the oxygen consumed is less, while the ratio of the free ammonia to the albuminoid ammonia is considerably increased. These features are clearly shown by the following table, where it will be noted that the ratio of free to albuminoid ammonia in the Lawrence Street sewage is 2.8 to 1, while in the station sewage it is 5.4 to 1.

Comparison of Yearly Averages of Fresh Sewage from Lawrence Street Sewer with the Stale Sewage pumped at the Station.

[Parts per 100,000.]

1894.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.
		Total.	Soluble.	Insoluble.		Nitrates.	Nitrites.		
Lawrence Street Sewer,	2.84	1.00	.61	.39	8.85	.0900	.0109	5.59	35
Regular Sewage,	3.43	.63	.26	.37	8.07	.0000	.0000	3.54	0

From the outset of these investigations it has been known that the nitrogen of the albuminoid ammonia in the sewage formed only a somewhat variable part of the total organic nitrogen. In order to determine this factor numerous comparative experiments by the Kjeldahl process were made in the earlier years of the station, and they showed that on an average about 50 per cent. of the organic nitrogen of the station sewage was obtained as albuminoid ammonia by the Wanklyn process. It may be added here that many of these analyses were made in the Boston laboratory, and the delay caused by the transportation of the samples is a matter worth considering in studying these results. It is to be borne in mind that the composition of the sewage has changed considerably during the past five years, as has been pointed out on page 457. Recently additional experiments have been made, and this factor has been found on an average to be about 40 per cent. at present.

Initial Steps in the Decomposition and Purification of Sewage.

The changes which fresh sewage undergoes, and the relative amounts of organic nitrogen yielded as albuminoid ammonia, are well shown by the following experiment, which is representative of a series which has been made in the laboratory. As it is generally supposed that sewage contains no free dissolved oxygen, it is plain that an important step in advance has been taken in our knowledge of sewage purification.

Table showing the Changes in Composition occurring in a Bottle of Fresh Lawrence Street Sewage upon standing.

[Parts per 100,000.]

Date.		Hour of Examination.	Ammonia.			Organic Nitrogen.				Nitrogen as Nitrates and Nitrites.	Total Nitrogen (Kjeldahl Method).	Oxygen Consumed.		Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
				Albuminoid.		$\frac{14}{17}$ Albuminoid Ammonia.		By Kjeldahl Method.							
Collection.	Examination.		Free.	Total.	Soluble.	Total.	Soluble.	Total.	Soluble.			2 Minutes.	5 Minutes.		
Mar. 11	Mar. 11	10.30 A.M.	2.25	.97	.71	.80	.58	4.03	3.14	.35	6.22	8.50	13.20	57	1,190,000
" 11	" 11	12.30 P.M.	2.50	1.00	.71	.82	.58	4.03	2.89	.31	6.39	8.10	14.20	60	1,085,000
" 11	" 11	3.00 P.M.	2.55	1.01	.71	.83	.58	3.96	2.89	.29	6.34	8.50	13.60	60	1,505,000
" 11	" 11	6.00 P.M.	2.85	1.01	.68	.83	.56	3.77	2.78	.25	6.36	8.50	13.30	30	1,530,000
" 11	" 12	8.00 A.M.	4.95	1.08	.60	.88	.49	2.38	1.16	.03	6.46	7.40	10.70	0	20,475,000
" 11	" 12	12 00 M.	5.00	1.13	.60	.92	.49	1.98	1.16	.02	6.10	6.90	9.80	0	23,100,000
" 11	" 12	5.00 P.M.	5.00	1.02	.51	.83	.42	2.17	1.16	.00	6.27	6.90	9.80	0	20,000,000
" 11	" 13	10.30 A.M.	5.10	1.00	.57	.82	.47	1.98	1.16	.00	6.16	6.00	8.90	0	12,810,000
" 11	" 14	10.30 A.M.	5.00	.95	.40	.78	.33	1.78	.94	.00	5.88	5.50	7.20	0	11,235,000
" 11	" 15	10.30 A.M.	5.00	.93	.41	.76	.34	1.76	.93	.00	5.76	4.90	6.80	0	6,825,000
" 11	" 16	10 30 A.M.	5.00	.93	.43	.76	.35	1.64	.75	.00	5.74	4.80	7.20	0	4,485,000
" 11	" 18	10.30 A.M.	5.10	.83	.37	.68	.30	1.43	.74	.00	5.61	5.10	7.00	0	3,420,000
" 11	" 19	10 30 A.M.	5.20	.84	.37	.69	.30	1.37	.59	.00	5.63	5.00	7.10	0	2,341,000

The sample of sewage was collected in a chemically clean and sterile glass bottle at the Lawrence Street sewer at 10 A.M. on March 11. The temperature of the sewage at the time of collection was 43° F., and at the time of the first analysis it was the same. During this and the following days analyses were made at frequent intervals of samples taken from this bottle. Particular attention was given to determining the state in which the nitrogen was present, and in each case the organic nitrogen was determined both by the Wanklyn (albuminoid ammonia) and by the Kjeldahl methods.* The temperature of the laboratory, it should be noted, ranged from 60° to 70° F.

* All determinations of organic nitrogen by the so-called Kjeldahl method have been made as follows: Five cubic centimeters of sewage have been placed in a distilling flask and the free ammonia driven off by a current of steam. Ten cubic centimeters of specially prepared sulphuric acid, free from nitrogen, are added, and the mixture heated over a free flame until the solution is colorless. It is then cooled and powdered potassium permanganate added until color appears, when 50 cubic centimeters of ammonia-free water are added. The solution is neutralized by a solution of caustic soda, distilled by the aid of a current of steam, and the distillate nesslerized and read as usual.

during the week in which these experiments were being carried out. These results show, upon standing twenty-four hours, an increase of over 100 per cent. in the amount of free ammonia in the sewage, and a total disappearance of the free dissolved oxygen and, practically, of the nitrates and nitrites. The amount of organic nitrogen by the Kjeldahl method decreased 67 per cent. during the experiment, while the relation of the albuminoid ammonia to the organic nitrogen changed from 20 per cent. at the beginning, to 50 per cent. at the end. The decrease in the amount of oxygen consumed after boiling two minutes and five minutes is seen to be 40 and 50 per cent. respectively. Another point worth mentioning is that, as the crude organic matter is converted to free ammonia, it is the soluble and not the insoluble portions which are the first to undergo this change.

The results of study in these lines are of value for two reasons: —

1. They give us a clearer conception of the initial step in the purification of organic matter by bacterial action, a process which is of the utmost importance in the economy of nature.

2. They pave the way for more substantial knowledge concerning the composition of sewage, and for more accurate data upon the capacity of various filtering materials to purify sewage, expressed in units of unpurified and unoxidized substances.

With a view to obtaining additional data upon the composition of sewage, there have been made during the past year four series of analyses of hourly samples of sewage from places in the State where there are purification plants in operation. The results of a similar series from the Lawrence Street sewer have already been presented on page 450. An outline of the conditions under which the samples were collected, with the methods of analyses, is next presented, and following this are the tables of analyses and a summary of the average results.

General Features of Series of Samples of Sewage collected Hourly.

All samples were collected at a time when there had been no rainfall for several days. The chemical samples were treated at once with mercuric acetate in the proportion of 1 part to 4,000, in order to kill the bacteria and to prevent decomposition, as illustrated by the last table, during transportation to the laboratory. As has been already stated, this treatment prevents an accurate determination of insoluble matters, but it has the decided advantage of enabling the

organic matters to be obtained without any decomposition after the time of collection. Determinations of dissolved oxygen were made on the spot from separate samples. Still another set of samples was diluted 1 to 500 with sterilized water, from which plantings for bacteria were made at once in glycerine agar, and the plates allowed to develop for four days at about 20° C. The oxygen consumed was determined after boiling for periods of two and five minutes, in order to obtain a connecting link between the methods of the Lawrence and Boston laboratories.

The only further comment necessary upon the methods of analyses is to state that the hardness means total hardness, sometimes called alkalinity, and was determined by titrating the samples against a sulphuric acid solution, using methyl orange as the indicator.

With the exception of the Worcester State Lunatic Hospital the data are inadequate for an accurate estimation of the number of persons contributing to the several sewage systems. This is chiefly so because a large percentage of the persons use the sewers for only a portion of the day. The approximate estimates which are used further on are based on the relation of the water flowing in sewers to the estimated average consumption per capita.

Special Features of Series of Sewage Samples collected Hourly.

Worcester State Lunatic Hospital.—This institution is situated on a hillside on the outskirts of the city, and beyond the limits of the city sewers. There was practically no ground water or surface water flowing into the sewer; in fact, all the water going to the sewer passed through a meter on the city service pipe. The number of inhabitants on June 26 and 27, the dates of collection, was about 950. The samples of sewage were collected at a man-hole several hundred feet from the buildings, and just above the settling tank, through which the sewage passes on its way to the irrigating field.

A very considerable portion of the water supply is used for laundry purposes, and this explains the high temperature of the sewage during the day. As the laundry is operated six days in the week, there is reason to believe that these results are representative.

Owing to the fact that the samples were collected only a very few minutes after entrance of the sewage into the sewers, the sewage uniformly contained dissolved oxygen, nitrogen as nitrates and nitrites, and the ratio of free ammonia to the organic nitrogen was

very low. Another proof of the freshness of the sewage was the fact that upon reaching the point of collection it contained in many instances undisintegrated fæces. This made it difficult to collect representative samples in some cases. The measurements of the flow of sewage were taken from meter readings, and the quantity per capita was found, upon consulting the records of the institution, to approximate very closely the average for a period of several months preceding this time.

Marlborough. — The sewerage system of this city is of the so-called separate type; but, as there are no underdrains beneath the sewers, a considerable quantity of ground water enters them. The length of the outfall sewer, from the last lateral to the point where it discharges into the settling tank on the filter field, is about four miles.

Samples of sewage were collected July 10 and 11 from the man-hole just as the sewage entered the settling tank. Measurements were made by noting the time taken to fill one of the compartments of this tank. It will be observed that the sewage contained no free dissolved oxygen during the maximum flow, although during the greater part of the day it was present. The longer period of time afforded for bacterial action due to the flow through the pipe gave a high ratio of free ammonia to organic nitrogen. It was found that during the maximum flow dissolved oxygen was absent in the outflow sewer below a man-hole 7,200 feet from the last lateral. The city water was found on this date to contain 65 bacteria per cubic centimeter, and 76 per cent. of dissolved oxygen necessary for saturation at the actual temperature.

Gardner. — The sewers in this town receive at time of rain some surface water, and a large amount of ground water enters them. Samples were collected July 26 and 27, as the sewage flowed into the settling tank on the filter field, which is about one mile distant from the outskirts of the village. In the last 1,050 feet of the outfall sewer, 12 inches in diameter, the sewage passes through an inverted siphon. Measurements were made of the quantity by noting the time taken to fill one of the compartments of the settling tank. Here, as at Marlborough, the free dissolved oxygen was absent during the maximum flow, but at no time was it found wanting in the sewage as it entered the siphon. It will also be noted that nitrates and nitrites were regularly present.

On the dates of collection of these samples the public water sup-

ply contained 130 bacteria per cubic centimeter, and 86 per cent. of free oxygen necessary for saturation at the actual temperature.

Framingham. — At this place there are underdrains beneath the principal sewers to carry off the ground water. Samples were collected September 11 and 12 as the sewage entered the collecting reservoir at the pumping station, about one mile distant from the village. Measurements of the quantity were taken from a gauge in the reservoir, together with pumping records when the pumps were in operation.

In addition to the samples collected at the above-mentioned point, analyses of three additional samples are given: first, sewage from the check valve of the pump a little while after it was started; second, sludge from this valve just before the pumps were stopped, and when there were less than six inches in depth of sewage in the collecting reservoir; third, from the underdrain beneath the main sewer.

The free dissolved oxygen was exhausted on several occasions during the maximum flow. At this time the public water supply contained 49 bacteria per cubic centimeter, and 85 per cent. of dissolved oxygen necessary for saturation at the actual temperature.

Results of analyses of this set of serial samples are as follows: —

Results of Analyses of Samples of Sewage collected Hourly from the Main Sewer at the Worcester State Lunatic Hospital.

[Parts per 100,000.]

Date — 1894.	Hour.	Rate of Flow. — Gallons Passed between Samples.	Temperature. Degrees F.	Ammonia.		Chlorine.	Organic Nitrogen by Kjeldahl Method.	Nitrogen as		Total Nitrogen. — Organic Nitrogen by Kjeldahl Method.	Oxygen Consumed.		Per Cent. of Dissolved Oxygen.	Hardness.	Fats.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.			Nitrates.	Nitrites.		2 Minutes.	5 Minutes.				
June 27, ...	4.30 P.M.	–	84	.35	.31	1.45	2.00	.03	.0008	2.29	2.80	4.80	54	5.7	3.6	1,795,000
" 27, ...	5.30 "	11,198	74	.65	.67	3.62	2.72	.03	.0010	3.25	6.50	15.60	53	6.7	4.4	1,944,000
" 27, ...	6.30 "	4,223	76	.90	1.03	3.63	3.80	.05	.0026	4.54	19.20	34.40	51	11.9	7.7	500,000
" 27, ...	7.30 "	2,798	68	.75	.30	2.15	2.31	.04	.0012	2.92	1.60	3.30	59	6.3	1.9	390,000
" 27, ...	8.30 "	1,665	69	.80	.43	1.55	1.88	.03	.0010	2.54	2.20	3.60	55	5.7	1.1	465,000
" 27, ...	10.00 "	150	68	.30	.14	.93	.74	.02	.0028	.99	.60	1.60	65	2.7	1.1	438,000
" 28, ...	5.15 A.M.	2,400	85	.13	.29	1.29	.61	.02	.0004	.72	5.80	9.10	79	3.8	1.7	966,000
" 28, ...	6.25 "	5,925	78	2.35	3.50	9.12	14.51	.02	.0010	16.43	11.60	19.40	51	11.5	10.4	574,000
" 28, ...	7.00 "	1,275	77	1.35	.61	3.23	4.38	.06	.0022	5.49	2.60	4.90	63	7.9	2.8	501,000
" 28, ...	8.00 "	5,475	77	.75	.48	4.44	3.05	.04	.0012	3.66	9.80	17.90	50	8.9	4.5	469,000
" 28, ...	9.00 "	5,550	83	.70	.74	2.67	2.97	.04	.0018	3.54	4.80	10.20	49	9.1	6.5	864,000
" 28, ...	10.00 "	4,575	89	.45	.59	1.88	2.07	.03	.0020	2.44	4.20	10.00	56	10.3	7.5	816,000
" 28, ...	11.00 "	3,600	79	.25	.42	2.18	1.18	.04	.0020	1.38	2.30	5.80	64	5.5	1.3	356,000
" 28, ...	12.00 M.	3,975	79	1.05	.52	4.66	3.72	.06	.0024	4.58	9.90	19.10	60	12.3	3.8	266,000
" 28, ...	1.00 P.M.	3,900	76	.45	.62	3.06	1.80	.02	.0008	2.17	9.70	21.10	57	7.2	5.1	224,000
" 28, ...	2.00 "	5,250	74	.70	.89	6.19	2.50	.06	.0022	3.07	6.90	11.40	50	16.6	6.8	1,254,000
" 28, ...	3.00 "	3,225	72	.60	.57	3.83	2.01	.06	.0028	2.50	3.90	8.00	60	6.3	2.8	1,054,000
" 28, ...	4.00 "	3,750	73	.48	.20	1.92	1.02	.02	.0008	1.41	.80	2.00	60	4.4	.2	558,000

Results of Analyses of Samples of Sewage collected Hourly from the Main Sewer at Marlborough.

[Parts per 100,000.]

Date — 1894.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature, Degrees F.	Ammonia.		Chlorine.	Organic Nitrogen by Kjeldahl Method.	Nitrogen as		Total Nitrogen. — Organic Nitrogen by Kjeldahl Method.	Oxygen Consumed.		Per Cent. of Dissolved Oxygen.	Hardness.	Fats.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.			Nitrates.	Nitrites.		2 Minutes.	5 Minutes.				
July 10, ...	11.00 A.M.	460,600	56	7.20	2.26	12.05	4.10	.02	.0000	10.03	8.10	12.90	0	33.0	8.4	2,077,600
" 10, ...	12.00 M.	473,760	57	7.40	2.97	8.65	6.34	.02	.0000	12.43	13.10	21.40	0	38.0	12.4	1,652,400
" 10, ...	1.00 P.M.	434,280	57	5.40	1.65	7.74	3.02	.02	.0000	7.47	8.10	11.10	0	29.0	12.1	2,529,200
" 10, ...	2.00 "	460,600	57	7.00	6.74	6.70	11.69	.03	.0012	17.48	27.40	36.00	0	38.0	73.6	2,937,600
" 10, ...	3.00 "	381,640	57	4.20	1.40	5.80	2.90	.01	.0000	6.37	7.90	11.70	0	27.0	7.5	2,019,600
" 10, ...	4.00 "	394,800	56	5.00	1.54	9.25	2.74	.02	.0000	6.88	7.90	11.30	0	22.0	8.0	2,133,200
" 10, ...	5.00 "	414,540	57	4.45	1.01	12.22	3.04	.02	.0000	6.72	5.40	7.60	2.8	36.0	7.9	1,958,400
" 10, ...	6.00 "	473,760	57	4.50	1.32	9.39	2.64	.02	.0000	6.37	8.80	12.80	0.0	32.0	16.7	1,897,200
" 10, ...	7.00 "	315,840	57	3.40	.84	7.70	1.64	.02	.0016	4.46	5.20	8.10	8.7	26.0	5.1	1,382,400
" 10, ...	8.00 "	394,800	57	3.70	.93	7.07	1.82	.03	.0020	4.90	4.60	6.40	4.8	28.0	16.3	1,497,600
" 10, ...	9.00 "	381,640	57	3.45	.57	5.32	1.25	.01	.0018	4.10	3.00	3.60	9.6	29.0	5.7	1,440,000
" 10, ...	10.00 "	381,640	57	4.45	.69	7.80	1.36	.02	.0014	5.05	4.60	6.30	6.7	33.0	4.1	1,396,000
" 10, ...	11.00 "	394,800	57	2.60	.47	7.60	.87	.02	.0012	3.03	2.80	3.50	9.6	24.0	1.1	1,219,600
" 10, ...	12.00 "	282,940	57	2.90	.56	6.25	1.16	.01	.0010	3.56	2.10	3.70	8.7	22.0	1.8	979,200
" 11, ...	5.00 A.M.	210,560	57	1.35	.15	4.57	.37	.09	.0120	1.58	.70	1.04	55.7	20.0	.2	960,000
" 11, ...	6.00 "	210,560	57	.75	.12	4.64	.40	.16	.0220	1.20	.70	.86	63.4	19.0	.0	633,400
" 11, ...	7.00 "	217,140	57	.53	.08	3.84	.38	.17	.0320	1.02	.40	.50	72.1	17.0	.0	633,600
" 11, ...	8.00 "	217,140	57	.35	.07	2.10	.36	.22	.0300	1.01	.44	.52	77.8	13.0	.1	570,000
" 11, ...	9.00 "	335,380	57	.30	.17	2.79	.34	.25	.0350	.87	.48	.52	84.6	11.2	3.6	675,200
" 11, ...	10.00 "	414,580	56	1.60	.74	5.55	1.38	.23	.0350	2.96	2.42	3.60	49.0	17.8	6.3	979,200

Results of Analyses of Samples of Sewage collected Hourly from the Main Sewer at Gardner.

[Parts per 100,000.]

Date — 1894.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. Degrees F.	Ammonia.		Chlorine.	Organic Nitrogen by Kjeldahl Method.	Nitrogen as		Total Nitrogen. — Organic Nitrogen by Kjeldahl Method.	Oxygen Consumed.		Per Cent. of Dissolved Oxygen.	Hardness.	Fats.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.			Nitrates.	Nitrites.		2 Minutes.	5 Minutes.				
July 26, ...	12.00 M.	241,500	67	1.50	.40	2.75	1.32	.03	.0036	2.59	2.30	4.10	5.3	9.6	2.2	1,101,600
" 26, ...	1.00 P.M.	236,250	66	1.65	.72	41.25	1.60	.09	.0130	3.06	2.60	6.80	2.7	11.8	1.5	921,600
" 26, ...	2.00 "	252,000	66	.90	.35	2.43	.94	.02	.0024	1.70	1.50	3.00	11.1	9.2	1.0	1,000,000
" 26, ...	3.00 "	252,000	66	.90	.36	2.50	.78	.02	.0008	1.54	2.00	3.00	0.0	10.2	1.1	1,530,000
" 26, ...	4.00 "	241,500	66	1.50	.68	2.26	1.68	.02	.0012	2.94	3.90	5.60	1.6	10.6	2.0	1,157,000
" 26, ...	5.00 "	236,250	66	1.00	.20	1.51	.84	.03	.0010	1.69	1.60	2.40	5.6	9.8	1.2	856,800
" 26, ...	6.00 "	252,000	66	1.30	.30	2.42	1.16	.06	.0070	2.24	1.40	1.90	8.1	9.6	.6	921,600
" 26, ...	7.00 "	168,000	66	1.35	.30	2.67	1.16	.03	.0026	2.30	1.60	2.00	5.6	9.4	.9	691,200
" 26, ...	8.00 "	157,500	66	1.70	.37	2.63	.87	.02	.0022	2.29	2.10	2.40	2.6	10.2	1.0	864,000
" 26, ...	9.00 "	157,500	65	1.05	.20	1.90	.57	.02	.0016	1 45	1.50	1.80	3.3	8.0	1.1	795,600
" 26, ...	10.00 "	152,300	64	1.00	.20	1.69	.52	.02	.0016	1.36	1.40	1.80	3.9	8.6	.7	795,600
" 26, ...	11.00 "	144,400	64	1.10	.23	1.60	.71	.02	.0028	1.64	1.30	1.50	3.5	7.8	.7	918,000
" 27, ...	5.00 A.M.	136,500	64	.10	.04	.85	.16	.04	.0018	.23	.32	.48	45.0	3.8	.1	238,000
" 27, ...	6.00 "	157,500	64	.10	.04	1.08	.21	.05	.0016	.34	.26	.38	49.0	3.6	.2	204,000
" 27, ...	7.00 "	210,000	64	.64	.24	1.22	.60	.03	.0018	1.16	.90	1.10	34.4	6.6	.9	856,000
" 27, ...	8.00 "	278,250	64	1.85	1.13	1.91	2.44	.03	.0012	3.99	4.50	5.60	0.0	11.4	5.3	2,142,000
" 27, ...	9.00 "	267,750	64	2.05	1.01	2.63	2.54	.03	.0004	4.26	4.10	5.10	0.0	13.6	3.6	1,346,400
" 27, ...	10.00 "	278,250	64	1.95	.75	3.21	2.46	.02	.0004	4.08	4.40	7.20	0.0	14.4	6.1	1,409,600
" 27, ...	11.00 "	257,250	64	1.55	.44	2.58	1.13	.02	.0006	2.43	3.80	9.40	0.5	10.8	2.5	1,897,200
" 27, ...	12.00 M.	246,700	64	1.90	.44	2.39	1.04	.03	.0016	2.63	2.00	2.60	3.1	11.6	3.0	1,409,000

Results of Analyses of Samples of Sewage collected Hourly from the Main Sewer at Framingham.

[Parts per 100,000.]

Date — 1894.	Hour.	Rate of Flow. — Gallons passed between Samples.	Temperature. Degrees F.	Ammonia.		Chlorine.	Organic Nitrogen by Kjeldahl Method.	Nitrogen as		Total Nitrogen. — Organic Nitrogen by Kjeldahl Method.	Oxygen Consumed.		Per Cent. of Dissolved Oxygen.	Hardness.	Fats.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.			Nitrates.	Nitrites.		2 Minutes.	5 Minutes.				
September 11, . .	11.00 A.M.	0	61	5.80	1.27	7.58	3.25	.04	.0100	8.08	8.40	11.20	0.0	31.5	3.6	1,750,000
" 11, . .	12.00 M.	8,015	62	4.90	.84	7.68	1.93	.04	.0080	6.02	6.80	9.40	4.0	32.0	1.2	1,232,000
" 11, . .	1.00 P.M.	7,263	62	3.80	.83	7.92	1.84	.15	.0230	5.81	7.20	11.00	10.0	26.5	4.9	1,330,000
" 11, . .	2.00 "	7,263	62	5.50	1.25	9.21	3.00	.00	.0010	7.53	11.80	15.00	0.0	33.5	10.9	2,012,000
" 11, . .	3.00 "	5,810	62	4.50	.95	7.08	2.57	.00	.0020	6.28	9.00	14.80	7.0	29.0	9.7	2,191,000
" 11, . .	4.00 "	6,161	62	3.90	1.06	7.09	2.48	.04	.0120	5.74	7.90	10.40	6.0	26.5	14.0	1,708,000
" 11, . .	5.00 "	6,161	62	3.60	.71	6.90	1.69	.02	.0080	4.68	6.30	8.50	15.0	25.0	6.5	1,400,000
" 11, . .	6.00 "	5,934	62	4.00	.84	5.67	1.80	.00	.0030	5.09	6.30	7.60	6.0	23.0	8.1	1,638,000
" 11, . .	7.00 "	5,934	62	4.10	.79	5.52	1.61	.19	.0250	5.20	4.40	6.20	21.0	21.6	4.9	1,760,000
" 11, . .	8.00 "	5,934	62	5.05	1.25	6.76	2.41	.01	.0010	6.57	7.10	9.20	0.0	29.5	14.1	1,883,000
" 11, . .	9.00 "	5,934	62	3.30	.81	4.63	2.18	.01	.0030	4.91	4.80	6.90	0.8	23.0	8.6	1,701,000
" 11, . .	10.00 "	3,956	61	2.50	.40	3.52	1.18	.01	.0020	3.25	3.70	5.30	12.0	18.2	3.7	1,960,000
" 12, . .	5.00 A.M.	29,340	59	.40	.06	1.53	.18	.01	.0050	.52	.80	1.10	28.0	8.2	0.5	945,000
" 12, . .	6.00 "	4,890	59	.41	.05	1.60	.18	.01	.0050	.53	.70	.80	30.0	8.8	0.2	493,000
" 12, . .	7.30 "	7,335	59	1.00	.19	1.91	.61	.01	.0050	1.44	1.70	2.00	23.0	9.6	2.4	525,000
" 12,* . .	8.00 "	10,215	60	3.50	.43	4.89	1.11	.00	.0000	3.99	3.60	4.60	7.0	24.0	2.8	1,150,000
" 12, . .	9.00 "	8,313	61	2.90	1.01	2.78	2.36	.01	.0000	4.75	4.70	7.50	1.0	18.4	5.3	1,600,000
" 12,† . .	10.00 "	10,740	61	6.00	5.40	6.24	11.12	.00	.0000	16.06	19.40	28.40	0.0	48.5	16.2	15,120,000
" 12, . .	11.00 "	8,384	62	5.50	1.73	8.52	2.82	.01	.0000	7.35	8.40	14.00	0.0	38.0	11.2	3,510,000
" 12,‡ . .	12.00 M.	10,167	–	.0680	.0044	5.61	–	.75	.0038	–	.06	.08	–	3.7	–	–

* From pump. † Sludge from pump. ‡ From under-drains.

The next set of tables, three in number, present, first, a representative analysis of the sewage flowing in the sewer at each place during the entire twenty-four hours; second, an analysis, and estimate of the quantity, of ground water entering the sewers; and third, a representative analysis of the sewage proper, that is, excluding constituents of the ground water and city water from the results.

At the Worcester State Lunatic Hospital there was practically no ground water in the sewer, and at the other places the analyses do not correspond in all cases to minimum amounts of each individual substance, but they are complete for the single sample considered to contain the least crude sewage. The quantities given for the ground water do not correspond exactly with analyses given, because it was found that the purest ground water flowed at the end of the outfall sewers in the early morning, after the regular use of the sewers of the day had begun, and when the increased flow in the lateral sewers pushed forward the ground water a little more rapidly than when nothing else entered the sewers.

Table showing Analyses of Sewage representing the entire Day's Flow at Each Place.

Lawrence Street Sewer, Lawrence.

[Parts per 100,000.]

Total Flow during 24 Hours. — Gallons.	Temperature, Degrees F.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Organic Nitrogen. $\frac{14}{17}$ Albuminoid Ammonia.	Organic Nitrogen. Kjeldahl Method.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Total Nitrogen — Organic Nitrogen by Kjeldahl Method.	Oxygen Consumed. Boiled 2 Minutes.	Oxygen Consumed. Boiled 5 Minutes.	Per Cent. of Dissolved Oxygen.	Hardness.	Fats.	Bacteria per Cubic Centimeter.
965,400	65	1.82	.54	6.86	.44	1.85	.16	.0033	3.50	3.49	4.71	36.3	19.3	3.1	1,215,000
Worcester State Lunatic Hospital.															
68,900	78	.74	.72	3.40	.59	3.25	.05	.0015	3.91	6.46	12.85	56.8	8.3	4.5	871,000
Marlborough.															
343,000	57	3.67	1.30	6.95	1.06	2.48	.05	.0064	5.56	5.96	8.64	19.0	26.3	9.9	1,518,000
Gardner.															
200,000	64	1.17	.38	3.99	.31	1.12	.03	.0024	2.11	2.14	3.36	10.5	9.3	1.7	1,121,000
Framingham.															
147,600	60	3.09	.72	4.80	.59	1.67	.03	.0055	4.24	5.00	7.23	11.2	21.3	5.6	1,533,000

Table showing Analyses of Ground Water entering the Sewers at Each Place.

Lawrence Street Sewer, Lawrence.

[Parts per 100,000.]

Total Flow during 24 Hours. — Gallons.	Temperature. Degrees F.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Organic Nitrogen. $\frac{14}{17}$ Albuminoid Ammonia.	Organic Nitrogen. Kjeldahl Method.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Total Nitrogen. — Organic Nitrogen by Kjeldahl Method	Oxygen Consumed. Boiled 2 Minutes.	Oxygen Consumed. Boiled 5 Minutes.	Per Cent. of Dissolved Oxygen.	Hardness.	Fats.	Bacteria per Cubic Centimeter.
517,000	62	.50	.06	2.91	.05	.38	.25	.0190	1.06	.50	.90	53	11.0	0.6	260,000
Marlborough.															
210,000	57	.35	.07	2.10	.05	.36	.22	.0300	0.90	.44	.52	78	13.0	0.1	570,000
Gardner.															
136,500	64	.10	.04	0.85	.03	.16	.04	.0018	0.28	.32	.48	45	3.8	0.1	238,000
Framingham.															
46,700	59	.41	.05	1.60	.04	.18	.01	.0050	0.53	.70	.80	30	8.8	0.2	493,000

Table showing Nitrogen, Chlorine, Oxygen consumed, Fats and Bacteria in Sewage from Each Place, after deducting from the Representative Analyses the Amounts of these Constituents in Ground Water and Public Water Supply.

[Parts per 100,000.]

Place.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Organic Nitrogen. $\frac{14}{17}$ Albuminoid Ammonia.	Organic Nitrogen. Kjeldahl Method.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Total Nitrogen. — Organic Nitrogen by Kjeldahl Method.	Oxygen Consumed. Boiled 2 Minutes.	Oxygen Consumed. Boiled 5 Minutes.	Fats.	Bacteria per Cubic Centimeter.
Lawrence Street sewer, Lawrence.	1.32	.46	3.75	.38	1.45	.00	.0000	2.53	2.73	3.40	2.5	955,000
Worcester State Lunatic Hospital.	0.74	.70	3.25	.57	3.20	.00	.0000	3.81	1.76	3.81	4.5	871,000
Marlborough, . . .	3.30	1.21	4.50	.99	2.04	.00	.0000	4.75	5.32	7.82	9.8	948,000
Gardner, . . .	1.07	.33	2.90	.27	.96	.00	.0000	1.84	1.70	2.70	1.6	883,000
Framingham, . . .	2.68	.67	2.70	.55	1.49	.00	.0000	3.69	4.24	6.34	5.4	1,040,000

Comparison of Relative Amounts of Substances in Sewage.

In the following table are presented comparisons of relative amounts of different substances in the several sewages, as indicated by the results of analyses of representative samples for twenty-four hours' flow: —

Table showing Comparison of Relative Amounts of Different Substances in Representative Sewage from the Several Places aforesaid.

Nitrogen as Albuminoid Ammonia (Wanklyn) with Organic Nitrogen (Kjeldahl).

[Parts per 100,000.]

	Worcester State Lunatic Hospital.	Marlborough.	Gardner.	Framingham.	Lawrence Street Sewer.	Experiment Station.
Nitrogen as albuminoid ammonia (Wanklyn),	.59	1.07	.31	.59	.44	.52
Organic nitrogen (Kjeldahl), ...	3.25	2.48	1.12	1.67	1.85	1.30
Per cent. which former is of latter, . . .	18	43	28	35	24	40
Per cent. of dissolved oxygen, ...	56.8	19.0	10.5	11.2	36.6	0

Nitrogen as Free Ammonia with Total Nitrogen (Kjeldahl).

	Worcester State Lunatic Hospital.	Marlborough.	Gardner.	Framingham.	Lawrence Street Sewer.	Experiment Station.
Nitrogen as free ammonia, ...	.61	3.01	.95	2.53	1.49	2.81
Total nitrogen (Kjeldahl), ...	3.62	5.56	2.11	4.27	3.45	4.11
Per cent. which former is of latter, . . .	17	54	45	60	43	68

Oxygen Consumed, determined after boiling 2 minutes and 5 minutes.

	Worcester State Lunatic Hospital.	Marlborough.	Gardner.	Framingham.	Lawrence Street Sewer.	Experiment Station.
Oxygen consumed after two minutes, . .	6.46	5.96	2.14	5.00	3.49	3.54
Oxygen consumed after five minutes, . .	12.85	8.64	3.36	7.23	4.71	-
Per cent. which former is of latter, . . .	50	69	64	69	74	-

Total Nitrogen (Kjeldahl) with Oxygen Consumed after 2 minutes.

	Worcester State Lunatic Hospital.	Marlborough.	Gardner.	Framingham.	Lawrence Street Sewer.	Experiment Station.
Total nitrogen (Kjeldahl), ...	3.62	5.56	2.11	4.27	3.45	4.11
Oxygen consumed after two minutes, . .	6.46	5.96	2.14	5.00	3.49	3.54
Per cent. which former is of latter, . . .	56	93	99	85	99	116

Total Nitrogen (Kjeldahl) with Chlorine.

	Worcester State Lunatic Hospital.	Marlborough.	Gardner.	Framingham.	Lawrence Street Sewer.	Experiment Station.
Total nitrogen (Kjeldahl), ...	3.62	5.56	2.11	4.27	3.45	4.11
Chlorine, ...	3.40	6.95	3.99	4.80	6.86	8.07
Per cent. which former is of latter, . . .	106	80	53	89	50	51

Total Nitrogen (Kjeldahl) with Fats.

	Worcester State Lunatic Hospital.	Marlborough.	Gardner.	Framingham.	Lawrence Street Sewer.	Experiment Station.
Total nitrogen (Kjeldahl), ...	3.62	5.56	2.11	4.27	3.45	4.11
Fats, ...	4.5	9.9	1.7	5.6	3.1	4.4
Per cent. which former is of latter, . . .	80	56	124	76	111	93

The chief points to be noticed in the above table are as follows: —

1. The amount of organic nitrogen represented by the albuminoid ammonia (Wanklyn method) was found to be a comparatively small and variable per cent. of that found by the Kjeldahl method. This percentage was lowest at the Worcester State Lunatic Hospital, where the sewage is freshest and the amount of dissolved oxygen is greatest; it was highest at the Experiment Station, where the sewage is most stale and where dissolved oxygen is absent.

2. The percentage which the nitrogen as free ammonia forms of the total nitrogen is also variable, and follows in a general way the percentage which the organic nitrogen of the albuminoid ammonia (Wanklyn method) forms of that by the Kjeldahl method, as referred to above.

3. The results obtained of the oxygen consumed after boiling two minutes and five minutes, respectively, vary within very narrow limits, and, generally speaking, results by the former method seem to be about two-thirds of those by the latter.

4. The last three comparisons are of less importance, but are presented as a matter of record.

Comparison of Amounts per Capita per Day of Substances contributed by the Estimated Populations to the Several Sewages.

In the table below are given the amounts per capita of the various substances contributed to the sewages from several places. The results do not include the substances in the ground water or in the public water supply. By this method the results are directly comparable, but it is to be remembered, as already stated, that the estimates of the numbers of persons using the sewers are only approximate. The estimates of the number of persons per day (of twenty-four hours) using the sewers, based to a large extent except at Worcester upon the consumption of water per capita, are as follows: Lawrence Street sewer, Lawrence, 7,000; Worcester State Lunatic Hospital, 950; Marlborough, 3,000; Gardner, 900; and Framingham, 2,500.

The figures in the table show a marked variation in the amount per capita of organic and other matters from sewages from different places. As it is clearly understood that the amount of crude organic matter in sewage has a practical bearing in estimating the capacity for purification of filtering materials, especially during the winter months, it is proposed to continue these investigations, and further discussion is deferred until more data are available.

Table showing the Average Amounts of Constituents contributed by the Estimated Population to the Sewage from the Several Places, expressed in Pounds per Capita per Day.

	Ammonia.			Organic Nitrogen.		Nitrogen as		Total Nitrogen.	Oxygen Consumed.			Bacteria.
	Free.	Ammonia.	Chlorine.	14/17 of the Albuminoid Ammonia.	Kjeldahl Method.	Nitrates.	Nitrites.	Kjeldahl Method.	After 2 Minutes.	After 5 Minutes.	Fats.	Billions.
Lawrence Street sewer, Lawrence.	.0150	.0050	.0427	.0043	.0165	.00	.0000	.0288	.0311	.0388	.0285	517
Worcester State Lunatic Hospital.	.0044	.0042	.0195	.0034	.0192	.00	.0000	.0229	.0106	.0229	.0270	251
Marlborough, . .	.0313	.0115	.0427	.0094	.0194	.00	.0000	.0451	.0505	.0743	.0931	432
Gardner, . . .	.0198	.0061	.0536	.0050	.0178	.00	.0000	.0340	.0314	.0499	.0296	247
Framingham, . .	.0134	.0033	.0135	.0027	.0074	.00	.0000	.0184	.0212	.0317	.0270	166

Influence of Temperature and Composition of Sewage upon Nitrification.

In the special report upon Purification of Sewage and Water, 1890, the description of the process of nitrification and the influence of various substances and conditions upon it form a very prominent feature. Detailed results of analyses and full accounts of the conditions were presented in this report, showing circumstances under which nitrification became established in the case of the several filters operated during the first two years of these investigations. In the last two reports, as well as in the present one, the results of analyses have been presented as monthly averages, and the account of the work of the filters has been outlined with less detail. In consequence of this, it is difficult in some cases to learn how quickly nitrification occurred in the newer filters, and to obtain data showing the work of the filters before nitrification became established, or during what may be called the "pre-nitrification period."

Accordingly there are presented in the following table the pre-nitrification results obtained from each filter up to Jan. 1, 1895. For the sake of systematizing the records, a unit of one square foot of filtering surface has been adopted in each case. All available results are included, but some of the earlier filters of very fine material, such as clay, peat and garden soil, in which nitrification never became established, do not appear. A few of the later filters are also omitted, because the filtering material was placed above the original under-drains, which, being seeded with nitrifying organisms, caused nitrification to appear from the outset.

In order that the pre-nitrification period might be marked by a

well-defined line, these results include all those obtained until the effluents showed 0.1000 part per 100,000 of nitrogen as nitrates, with a steadily increasing amount. It is true that nitrogen as nitrates appeared before reaching this amount, but it was somewhat variable in quantity, occasionally decreasing to almost nothing, so that, for the sake of uniformity and clearness, it was decided to adopt the above quantity as a limit for this period.

Table showing Summary of Results obtained for Each of the Several Sewage Filters during the Period of Pre-nitrification, 1887–94, Inclusive.

Number of Filter.	Effective Size. — Millimeters.	Rate of Flow. — Gallons per Acre Daily.	Date of Beginning of Experiment.	Number of Days after First Sewage was Applied before Nitrates appeared.	Number of Days after First Dose came through before Nitrates appeared.	Amount of Nitrogen Applied per Square Foot of Filtering Surface. — Pounds.	Amount of Nitrogen in Effluent, per Square Foot of Filtering Surface. — Pounds.	Difference between Amount of Nitrogen Applied and Effluent, per Square Foot of Filtering Surface. — Pounds.	Temperature of Effluents. Deg. F. Maximum.	Minimum.	Average.
1, .	.48	47,000	Jan. 10, 1888	84	83	.0102	.0038	.0064	40	35	37
2, .	.08	52,000	Dec. 19, 1887	155	143	.0169	.0028	.0141	50	34	38
3 A, .	{ .48 / .08 }	{ 35,000	Jan. 5, 1890	82	73	.0108	.0020	.0088	41	37	38
4, .	.04	47,000	Dec. 19, 1887	134	122	.0196	.0020	.0176	42	35	37
6, .	.35	38,000	Jan. 12, 1888	110	108	.0113	.0023	.0090	44	34	38
7, .	.35	42,000	Jan. 14, 1888	126	121	.0156	.0016	.0140	51	34	38
9 A, .	.17	120,000	Nov. 18, 1890	103	101	.0451	.0240	.0211	46	35	37
11, .	.35	30,000	Feb. 8, 1888	67	65	.0054	.0004	.0050	47	36	40
12, .	.48	30,000	Feb. 16, 1888	63	63	.0053	.0003	.0050	44	36	40
12 A, .	.19	320,000	July 25, 1892	4	3	.0013	.0003	.0010	78	72	74
13, .	.48	56,000	Feb. 29, 1888	44	42	.0065	.0005	.0060	44	36	41
13 A, .	.19	360,000	Sept. 27, 1893	10	9	.0184	.0151	.0033	59	55	56
14, .	.48	140,000	Feb. 29, 1888	32	31	.0098	.0022	.0076	44	36	41
15 B, .	5.10	160,000	July 25, 1892	12	12	.0106	.0030	.0076	75	70	72
15 C, .	5.10	480,000	Feb. 26, 1894	53	53	.0119	.0106	.0013	53	33	41
16 B, .	5.10	160,000	July 25, 1892	12	12	.0106	.0024	.0082	75	70	72
17 A, .	.17	50,000	Jan. 28, 1890	67	65	.0137	.0025	.0112	46	39	43
19, .	.17	47,000	Jan. 28, 1890	51	43	.0098	.0013	.0085	44	40	42
21 A, .	1.60	480,000	Mar. 19, 1894	55	55	.0174	.0111	.0063	61	42	50
22 A, .	–	240,000	Mar. 19, 1894	55	53	.0085	.0060	.0025	60	42	51
26, .	9.00	15,600	April 1, 1890	33	33	.0020	.0006	.0014	54	47	50
27, .	.48	55,800	April 1, 1890	30	29	.0073	.0023	.0050	54	47	50
28, .	.17	55,800	April 1, 1890	36	35	.0078	.0028	.0050	56	46	50
29, .	9.00	13,900	May 27, 1890	17	17	.0010	.0001	.0009	66	58	61
30, .	.48	55,800	May 27, 1890	13	12	.0029	.0007	.0022	62	58	60
31, .	.17	55,800	May 27, 1890	13	12	.0029	.0006	.0023	63	58	60
32, .	.17	185,000	Dec. 5, 1891	83	82	.0074	.0058	.0016	49	39	44

From the above results, which are summarized in the next table, we learn that, while ten days or less were sufficient in warm weather to allow nitrification to become established, a period of one hundred days or more was necessary in the case of some of the filters started during the winter. We also learn that the amount of stored nitrogen (more accurately, the difference between the amount applied and that in effluent) in the filters at the end of the pre-nitrification period was in some cases less than 5 per cent. of what it was in others.

Summary of Pre-nitrification Results, by Months.

Month.	Number of Filters Started.	Average Number of Days before Nitrates Appeared.	Average Amount of Nitrogen per Square Foot of Surface (Pounds).			Average Temperatures of the Effluents (Degrees F.).		
			Applied.	In Effluent.	Difference.	Maximum.	Minimum.	Average.
January, . .	6	82	.0119	.0022	.0097	44	36	39
February, . .	5	51	.0078	.0009	.0069	46	35	41
March, . . .	2	55	.0135	.0085	.0050	60	42	50
April, . . .	3	32	.0171	.0057	.0114	55	47	50
May, . . .	3	14	.0023	.0005	.0018	64	58	60
June, . . .	0	–	–	–	–	–	–	–
July, . . .	3	9	.0075	.0019	.0056	76	71	73
August, . . .	0	–	–	–	–	–	–	–
September, . .	1	10	.0184	.0151	.0033	59	55	56
October, . .	0	–	–	–	–	–	–	–
November, . .	1	101	.0451	.0240	.0211	46	35	37
December, . .	3	116	.0146	.0035	.0111	47	36	40

It will be noticed that the greater number of these filters were started during the cold season of the year. Partly with a view to obtaining more complete data upon the effect of temperature and of the season of the year, and partly for the sake of studying the influence of differences in the composition of sewage upon nitrification, a series of special experiments was started in June, 1894. During each month of the year a set of three tanks, 3.2 inches in diameter and 5 feet deep, has been filled with 4 feet 6 inches of sand, of an effective size of 0.26 millimeter.

To these tanks, placed within the building, sewage has been applied at the rate of 120,000 gallons per acre daily for six days in a week, as follows: To No. I., the regular station sewage, as

shown by analyses on page 452; No. II., regular station sewage, after a current of air had been drawn through it for twenty minutes; and to No. III., fresh sewage from the Lawrence Street sewer. The coefficient of absorption of air by "ordinary" sewage is not accurately known, but in these experiments the sewage contained, after aeration, from 80 to 90 per cent. of the oxygen necessary to saturate water at the actual temperature.

Monthly averages of weekly analyses of mixed samples, representing each day's dose of the sewage in the Lawrence Street sewer, are presented in the following table. These samples were collected at about 1 P.M.

*Monthly Averages of Analyses of Mixed Weekly Samples from Lawrence Street Sewer.**

[Parts per 100,000.]

1894.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Oxygen Consumed.
June,	1.78	.71	8.30	4.77
July,	2.04	1.21	13.27	7.53
August,	3.52	.93	7.71	6.70
September,	2.01	.84	14.57	7.04
October,	2.10	.85	6.91	6.15
November,	2.20	.79	8.23	6.25
December,	2.32	1.03	7.97	7.40
Averages,	2.28	.91	9.57	6.55

* Determinations were not made regularly of the nitrogen as nitrates and nitrites, but the former was present in amounts ranging from 0.01 to 0.20 part.

Frequent analyses have been made of the effluent of each filter of the several monthly sets, and from these results there have been collected the pre-nitrification results, after the same uniform scheme adopted for the regular sewage filters already presented.

With regard to the records of temperature in the table below, it is to be noted that they represent the results of observations from 5 A.M. to 6 P.M., and during the night, when the temperature fell, no records appear in the averages. In the case of large filters the temperature of the effluent varies during the day within very narrow limits, but this point is worth mentioning in connection with the small filters, where the material is more exposed to changes in the temperature of the air.

Summary of Pre-nitrification Results from Monthly Sets of Special Filters Nos. I., II. and III., June to December inclusive, 1894.

Number of Filters in the Set.	Experiment Begun.	Number of Days before Nitrification Appeared.	Amount of Nitrogen per Square Foot of Filtering Surface in Pounds.			Temperature of Effluent. Degrees F.		
			Applied.	In Effluent.	Difference.	Maximum.	Minimum.	Average.
I., . . .	June 7	4	.0036	.0004	.0032	79	64	70
II., . . .	" 7	4	.0036	.0005	.0031	79	64	70
III., . . .	" 7	4	.0023	.0005	.0018	79	64	70
I., . . .	July 6	4	.0037	.0002	.0035	77	70	74
II., . . .	" 6	4	.0037	.0002	.0035	77	70	74
III., . . .	" 6	4	.0037	.0007	.0030	77	70	74
I., . . .	Aug. 14	3	.0023	.0002	.0021	75	73	74
II., . . .	" 14	2	.0016	.0001	.0015	75	74	74
III., . . .	" 14	6	.0040	.0004	.0036	75	72	74
I., . . .	Sept. 11	6	.0040	.0002	.0038	69	64	67
II., . . .	" 11	6	.0040	.0002	.0038	69	64	67
III., . . .	" 11	6	.0038	.0004	.0034	69	64	67
I., . . .	Oct. 11	11	.0095	.0007	.0088	61	52	56
II., . . .	" 11	11	.0095	.0005	.0090	61	52	56
III., . . .	" 11	11	.0072	.0011	.0061	61	52	56
I., . . .	Nov. 12	59	.0617	.0225	.0392	52	32	42
II., . . .	" 12	59	.0617	.0243	.0374	52	32	42
III., . . .	" 12	62	.0506	.0252	.0254	52	32	42
I., . . .	Dec. 18	37	.0356	.0115	.0241	50	32	41
II., . . .	" 18	44	.0424	.0166	.0258	50	32	41
III., . . .	" 18	84	.0533	.0480	.0053	50	32	41
IV., . . .	Jan. 9	15	.0140	.0020	.0120	53	45	49

From these results, obtained under the stated conditions, the following points may be set forth : —

1. Nitrification became established in each case in from two to six days, when the average temperature of the effluent was between 67° and 74° F. ; in eleven days at 56° ; and in thirty-seven days or more, when the average temperature was 45° or less.

2. The increase of 3° in the average temperature of the December experiments, owing to improved heating facilities, caused nitrification to appear fifteen to twenty-two days earlier than in the corresponding November experiments.

3. Aeration of the station sewage has no apparent influence in hastening nitrification at any time during the year.

4. Nitrification in Filter No. III., which received fresh sewage from the Lawrence Street sewer, appeared much more slowly in cold weather than in the case of the other two filters receiving partially decomposed sewage. In warm weather there was only a slight difference, although No. III. required a longer time for complete nitrification to become established.

With regard to the individual results of analyses from each monthly set of experiments, there did not seem to be enough variation to make it worth while to present all of them in full; accordingly, as a matter of record, and to point out the difference in results in warm and cold weather, the individual analyses of the August and November sets only are presented (page 480).

Three points of practical importance are brought out by the detailed analyses beyond, as follows: —

1. During warm weather nitrification under the stated conditions appeared before the capacity of the filtering material to absorb the free ammonia of the applied sewage by chemical means was overtaxed.

2. During warm weather nitrification became practically complete in so short a time that, together with the above-mentioned condition, the effluent of the station sewage contained but little free ammonia at any time. This is also true to a large degree of the effluent of the sewage direct from the Lawrence Street sewer.

3. During cold weather the capacity of the filtering materials to absorb free ammonia in the applied sewage was overtaxed long before nitrification set in, and when it appeared it was not sufficiently complete to prevent comparatively large quantities of free ammonia from being present in the effluents.

In examining these individual results it is to be remembered that the sewage from the Lawrence Street sewer contains some nitrogen as nitrates.

Table showing Results of Individual Analyses of the August Set of Special Experiments upon Nitrification.

[Parts per 100,000.]

Date — 1894.	Filter No. I.				Filter No. II.				Filter No. III.			
	Ammonia.		Nitrogen as		Ammonia.		Nitrogen as		Ammonia.		Nitrogen as	
	Free.	Albuminoid.	Nitrates.	Nitrites.	Free.	Albuminoid.	Nitrates.	Nitrites.	Free.	Albuminoid.	Nitrates.	Nitrites.
Aug. 15, .	.0240	.0280	.06	.0300	.0820	.0500	.03	.0280	.0760	.0620	.10	.0200
" 16, .	.0300	.0300	.04	.0800	.0700	.0380	.10	.0700	.1160	.0480	.07	.0500
" 17, .	.0440	.0380	.31	.0800	.0700	.0360	.28	.0700	.0960	.0580	.20	.0600
" 18, .	.0320	.0300	.42	.0700	.0560	.0300	.26	.0600	.1140	.0600	.24	.0400
" 20, .	.0540	.0280	1.94	1.0000	.0640	.0380	1.11	.6000	.0320	.0580	1.04	.7000
" 22, .	.0100	.0180	1.52	.1400	.0340	.0340	1.15	.5000	.4000	.0540	.99	.3000
" 25, .	.0340	.0480	3.75	.1000	.0260	.0220	4.28	.4000	.5000	.0540	3.00	.3000

Table showing Results of Individual Analyses of the November Set of Special Experiments upon Nitrification.

[Parts per 100,000.]

Date — 1894.	Filter No. I.				Filter No. II.				Filter No. III.			
	Ammonia.		Nitrogen as		Ammonia.		Nitrogen as		Ammonia.		Nitrogen as	
	Free.	Albuminoid.	Nitrates.	Nitrites.	Free.	Albuminoid.	Nitrates.	Nitrites.	Free.	Albuminoid.	Nitrates.	Nitrites.
Nov. 13, .	.0500	.0700	.02	.0360	.0440	.0420	.02	.0300	.0700	.1180	.02	.0480
" 15, .	.0400	.0620	.01	.0040	.0420	.0540	.01	.0060	.0400	.1000	.02	.0300
" 17, .	.0800	.0500	.07	.0040	.1000	.0600	.04	.0040	.0500	.0960	.25	.0140
" 20, .	.3500	.0540	.00	.0020	.3800	.0620	.00	.0020	.1820	.0820	.10	.0120
" 22, .	.7800	.0760	.00	.0060	.8000	.0740	.00	.0080	.3800	.0660	.03	.0180
" 24, .	1.3000	.0880	.00	.0060	1.4000	.0860	.00	.0060	.7000	.0760	.00	.0120
" 27, .	1.8800	.1360	.00	.0040	1.8800	.1360	.00	.0040	1.2000	.1120	.00	.0120
Dec. 3, .	3.3800	.2280	.00	.0160	4.2000	.2140	.00	.0280	2.3600	.2240	.05	.0580
" 5, .	2.8400	.1240	.00	.0060	4.1000	.1060	.00	.0040	2.0800	.1160	.14	.0080
" 6, .	3.3500	.2000	.02	.0040	3.6500	.1400	.02	.0040	2.2500	.1300	.14	.0060
" 8, .	2.0000	.1200	.02	.0080	2.0000	.1180	.02	.0060	2.4000	.1380	.14	.0120
" 11, .	3.9600	.1160	.00	.0040	3.5600	.1320	.00	.0060	3.2000	.1800	.10	.0120
" 13, .	3.6500	.1100	.00	.0080	3.7000	.1600	.00	.0060	2.8500	.1800	.10	.0100
" 15, .	3.2000	.0640	.03	.0140	3.2000	.1360	.03	.0080	2.5600	.1360	.16	.0100
" 19, .	3.6000	.1320	.10	.0100	3.5000	.1100	.07	.0040	3.7500	.1100	.20	.0100
" 22, .	3.5000	.2000	.09	.0140	3.4500	.1400	.09	.0060	3.5000	.1800	.08	.0080
1895.												
Jan. 1, .	3.5000	.1700	.05	.0060	3.5500	.2800	.04	.0060	4.0500	.2300	.15	.0100
" 9, .	4.0000	.1600	.15	.0210	4.0500	.1400	.15	.0060	.9500	.1200	.11	.0070
" 16, .	4.0000	.1300	.20	.0200	4.2500	.2900	.25	.0150	3.9500	.3500	.03	.0070
" 23, .	4.4500	.1500	.38	.0280	4.2500	.2300	.39	.0120	3.0500	.2000	.13	.0080
" 30, .	4.0000	.1800	.55	.0140	4.9500	.1300	.62	.0120	3.5000	.1500	.22	.0180
Feb. 6, .	4.0000	.3200	.60	.0300	3.7000	.2600	.85	.0340	3.6000	.3600	.00	.0500
" 12, .	3.5000	.1000	1.32	.0700	3.2500	.1200	1.77	.0520	3.5500	.2000	.32	.0300
" 20, .	3.0500	.1400	1.72	.0420	3.0500	.1600	2.17	.0320	4.1000	.1900	.61	.0200
" 27, .	2.6500	.1100	1.90	.0560	2.2000	.1400	2.17	.0320	3.4500	.1800	.53	.0440
Mar. 13, .	.6500	.0700	2.59	.1400	.6500	.0600	2.37	.0500	2.5000	.1000	1.32	.1550
" 27, .	.0800	.1000	2.56	.0700	.0400	.0700	2.51	.0400	.4000	.0800	2.03	.2200

Experiments to show the Influence upon Nitrification during Midwinter of Comparatively High and Very Low Temperatures.

On Jan. 9, 1895, a four-inch galvanized iron tank (Filter No. IV.) was filled with some of the same grade of material as was used for the regular monthly sets of nitrification experiments, and received station sewage at the rate of 120,000 gallons per acre daily for six days in a week. It was placed in a warmer location than were the filters started in November and December.

During the pre-nitrification period the maximum temperature of the effluent was 53°, the minimum 45° and the average 50° F. Nitrification became well established sixteen days after the first dose was applied, as is shown by the table of analyses beyond. The amounts of nitrogen applied to the filter, present in the effluent, and stored in the filter (obtained by difference) during this period were 0.0140, 0.0020 and 0.0120 pound, respectively, per square foot of filtering area. Upon the comparison of these results with similar ones obtained in August and November, it will be seen that they correspond much more closely with the former, particularly with regard to the appearance in a short time of high amounts of nitrites.

On February 22 nitrification was well established, and after the filter was well drained it was exposed to outdoor temperatures, with no application of sewage, for one week, during which the average maximum and minimum temperatures of the air were 35° and 10° F. respectively. On March 1 it was replaced in the building, and sewage again applied as usual. The sand was not frozen on this date, although the temperature on earlier dates was much below 32° F. Owing to the small diameter of the tank, the exposure of the filtering material to the cold was more complete than is the case with filter fields. This condition may not be so abnormal, however, as would appear at first sight, because in filter fields, as well as in experimental filters, the nitrifying organisms, as is the case with the organic matter, appear to be largely present in the surface layers and upper portions of the material, where the exposure to the cold is much greater than in the lower layers.

The results which are presented in the next table show that nitrification practically disappeared after March 1, and they lead to the following conclusions : —

1. Nitrification in sewage filters may become established in midwinter at an average temperature of 50° F. in the comparatively short period of sixteen days.

2. Nitrification may be destroyed in a filter which has been drained, by exposure to an average mean temperature of 22° F. for one week under the conditions supplied to Filter No. IV.

3. Storage of organic matter in filtering materials plays a far less important part in the establishment of nitrification than does temperature, although it is of course necessary to have some food present for the organisms to live upon. From other experiments it appears, however, that the intensity of nitrification depends to a considerable extent upon the storage of organic matter.

4. The time necessary to re-establish nitrification was practically the same as if the filter were new; but whether the organisms were killed by the exposure to the cold, or only affected so that their functions were temporarily interrupted, cannot be stated at present.

Table showing Results of Analyses of Effluent of Special Filter No. IV.

[Parts per 100,000.]

Date.	Ammonia.		Nitrogen as	
	Free.	Albuminoid.	Nitrates.	Nitrites.
Jan. 11,	.3500	.0920	.05	.0080
12,	.0700	.0560	.02	.0160
14,	.0820	.0580	.00	.0160
15,	.0700	.0680	.02	.0200
16,	.0700	.0800	.01	.0400
17,	.0700	.0600	.00	.0600
18,	.1200	.0600	.00	.1000
19,	.1900	.0580	.00	.2500
21,	.4500	.0600	.00	.3000
22,	.6000	.0600	.00	.6000
23,	.7000	.0600	.00	.9000
24,	.9600	.0680	.15	.7000
25,	1.2400	.0520	.59	.7000
26,	1.7500	.1100	.41	.8000
28,	1.7500	.1100	.83	1.0000
Feb. 6,	.8500	.1400	1.10	1.1000
12,	.1100	.0780	1.47	.7500
20,	.3500	.1000	2.37	.7500
Mar. 5,	.6500	.1300	.15	.0140
13,	2.9000	.1400	.09	.0080
20,	3.5000	.1500	.20	.0060
27,	3.6500	.1400	.21	.0100
April 5,	3.5000	.1600	1.67	.0040
10,	2.7500	.2200	2.50	.1500

Experiments to show the Influence upon Nitrification of Seeding Filters with Different Materials.

On February 23 three small tanks were filled with 4.5 feet of sand, as follows: Filter No. V. contained, in addition to the usual material, 5 per cent. of sand taken from the surface of Filter No. 12 A, mixed evenly through the whole mass; Filter No. VI. contained soil taken under the snow from the surface of a garden, mixed in the same manner and proportion as No. V.; and No. VII. was filled wholly with new sand from the same lot that has been used for all these special nitrification experiments, beginning in June, 1894. Upon applying station sewage to each of these filters at a rate of 120,000 gallons per acre daily for six days in a week, and when the average temperature of the effluent was 58° F., it was found that well-marked nitrification appeared in No. V. after three days; in No. VI. after eighteen days at 60° F.; and in No. VII. after twenty-three days at 60° F.

These experiments, confirmed by additional ones, show: —

1. That a small portion of material containing nitrifying organisms in an active state, when mixed with new sand in a filter, enables nitrification to become well established in three days, even at the comparatively low temperature of 58° F.

2. That long exposure to the cold of material known to be rich in nitrifying organisms during warm weather reduces the activity of these organisms practically to zero, and that such material upon mixture with new sand is of little aid in hastening nitrification.

The results of analyses are as follows: —

Table showing Results of Analyses of Effluents of Special Filters Nos. V., VI. and VII.

[Parts per 100,000.]

DATE — 1895.	FILTER NO. V.				FILTER NO. VI.				FILTER NO. VII.			
	AMMONIA.		NITROGEN AS		AMMONIA.		NITROGEN AS		AMMONIA.		NITROGEN AS	
	Free.	Albuminoid.	Nitrates.	Nitrites.	Free.	Albuminoid	Nitrates	Nitrites.	Free.	Albuminoid.	Nitrates.	Nitrites.
Feb. 26, .	.4100	.0680	2.16	.0420	.5000	.0700	.14	.0260	.5500	.0600	.14	.0300
Mar. 1, .	.3500	.0600	3.00	.0500	.3500	.0800	.10	.0150	.6500	.0700	.04	.0150
" 6, .	.1500	.0300	2.63	.0150	.6500	.0900	.12	.0320	.8500	.0800	.04	.0160
" 13, .	.1500	.0300	2.88	.0200	1.3000	.0600	.68	.2000	1.5000	.0900	.04	.0550
" 18, .	.0700	.0300	2.84	.0200	1.7500	.0700	3.46	.0200	1.6000	.1500	.20	.1550
Apr. 4, .	.0100	.0280	3.03	.0120	.0260	.0260	2.20	.0180	1.3800	.0800	3.27	.2500
" 9, .	.0100	.0360	4.45	.0060	.0200	.0280	3.51	.0140	.3000	.0720	5.60	.2500

Nitrification not Seriously interrupted by Washing Filtering Materials.

Instructive experiments have been made, showing that well-nitrified effluents from filters of either coarse or fine material, when mixed with crude sewage, have little influence in hastening nitrification. All results go to show that thorough purification by filtration requires the nitrifying organisms in an *active state* to be attached to the grains of filtering material.

In this connection it is interesting to call attention to the fact that washing the sand and gravel does not seem to remove these organisms so as to seriously interrupt the process of nitrification.

The chief features of our present knowledge upon nitrification have been pointed out sufficiently in the present section; but it will be found that some of the more practical points are discussed at greater length in subsequent sections, upon resting sewage filters, page 492, and upon the effect of winter weather upon the purification of sewage by intermittent filtration, page 513.

Average Purification of Sewage by the Several Filters in 1894.

In the following table are given the average results, showing the qualitative and quantitative efficiency of the several filters to which ordinary sewage has been applied. The removal of organic matter is indicated both by albuminoid ammonia and by oxygen consumed.

As a matter of convenience, some of the more important statistics concerning the construction and history of the filters are also presented. Outlines of the operation and results of analyses for the year 1894 will be found on pages 542–572. A discussion of some of the more important features of the results are given in the following sections. A summary of the results upon the remaining sewage filters during the past year appears in the section upon "Rapid filtration of sewage from which sludge has been removed by different methods," pages 536–541. The average purification of sewage by the several out-door filters, 1888 to 1894, inclusive, is shown by years, and is discussed on pages 497–531.

Average Per Cent. of Albuminoid Ammonia, Oxygen consumed and of Bacteria, removed from Sewage by the Several Filters, with Average Rates of Filtration, 1894.

Number of Filter.*	Dimensions of Filters. Depth of Sand. Inches.	Mean Diameter. Inches.	Area in Fractions of an Acre.	Size of Sand. Effective Size in Millimeters, 10 per Cent. Finer than —	Uniformity Coefficient.	Manner of Filling.	In Operation since —	Average Rate of Filtration. Gallons per Acre Daily, Six Days in a Week.	Average Per Cent. Removed of — Albuminoid Ammonia.	Oxygen Consumed.	Bacteria.
1, .	63	200	$\frac{1}{200}$	.48	2.4	Wet.	Jan. 10, 1888.	76,000	91	89	94
2, .	60	200	$\frac{1}{200}$	.08	2.0	Wet.	Dec. 19, 1887.	43,900	97	96	99.95
4, .	60	200	$\frac{1}{200}$	.04	2.7	Wet.	Dec. 19, 1887.	20,100	95	89	99.99
5 A, .	63	200	$\frac{1}{200}$	1.40	2.4	Dry.	Sept. 14, 1891.	90,600	88	85	92
6, .	44	200	$\frac{1}{200}$	.35	7.8	Wet.	Jan. 12, 1888.	54,300	94	89	99.2
7, .	44	200	$\frac{1}{200}$	.35	7.8	Wet.	Jan. 14, 1888.	13,800	98.5	97	99.99
9 A, .	60	200	$\frac{1}{200}$	.17	2.0	Dry.	Nov. 18, 1890.	74,500	94	92	99.0
10, .	60	200	$\frac{1}{200}$	.35	7.8	Dry.	July 18, 1894.	40,200	97	95	99.3
11 A, .	60	20	$\frac{1}{20,000}$	.35	7.8	Dry.	Mar. 30, 1892.	59,800	88	84	93
15 B, .	65	20	$\frac{1}{20,000}$	5.10	2.0	Dry.	July 25, 1892.	473,000	56	53	78
16 B, .	65	20	$\frac{1}{20,000}$	5.10	2.0	Dry.	July 25, 1892.	463,300	72	70	82
17 A, .	60	20	$\frac{1}{20,000}$	.17	2.0	Wet.	Jan. 28, 1890.	59,700	97	94	99.99
21 A, .	60	20	$\frac{1}{20,000}$	1.40	2.4	Dry.	Mar. 19, 1894.	467,000	89	87	96
22 A, .	60	20	$\frac{1}{20,000}$	-	-	Dry.	Mar. 19, 1894.	260,300	95	72	98
30, .	30	17	$\frac{1}{27,000}$	.48	2.4	Dry.	May 31, 1890.	55,600	93	91	98
31, .	30	17	$\frac{1}{27,000}$	.17	2.0	Dry.	May 31, 1890.	51,800	91	89	98.8

* Nos. 1–10 are placed out of doors; the others are placed within the buildings.

The qualitative results obtained from the older filters are somewhat better, on the whole, than those obtained in 1893. This is particularly the case with the larger filters placed out of doors (Nos. 1 to 9 A); the rates of filtration, however, have been reduced in several cases, instead of removing and replacing the surface layers, as is stated under the "management of filters." The new filters, Nos. 21 A and 22 A, have given results which are among the most satisfactory yet obtained at the station. An outline of these experiments will be found beyond.

Bacterial Purification.

Considerable attention has been given to the species of bacteria found in the effluents of Filters Nos. 2 and 4. Under normal conditions the bacteria (0 to 50 per cubic centimeter, as compared with

500,000 to 3,000,000 in sewage) have been found to be chiefly *B. fluorescens liquefaciens*, *B. proteus*, *B. candicans*, *B. circulans* and *B. subtilis*, none of which, so far as is known, is in any way injurious to health. These species, moreover, are not the prevailing ones in the applied sewage. When there is clogging in the upper layers and nitrification is impaired, the number of bacteria in the effluents usually increases. It appears from the study of the bacteria in the effluents that they arise from the growth of a very few hardy species in the filters, and that they do not pass through from top to bottom. With the experimental filters of coarser material there has been found to be a more or less direct connection between the bacterial flora of the effluents and that of the sewage; as is the case with the finer filters, the bacterial purification is greatest when the conditions for nitrification and other processes are most favorable.

Permanency of Sewage Filters.

The permanency of sewage filters is regarded as the ability of the main body of material below the upper six inches to purify sewage, under proper conditions of filtration, for an indefinite time. The sludge, fats and other organic matters in sewage are deposited in the upper layers of the filter, and this portion requires especial attention from time to time to secure continuous efficiency, as is noted in the next chapter, under "management of filters." In the annual report of the Board for 1893 it was shown that the average storage of nitrogen in the filters was no greater at the end than at the beginning of the year. In the present report the evidence upon the storage and removal of organisms with regard to the permanency of filters is presented along two lines: first, the consideration of nitrogenous matters; and, second, that of fats.

Storage and Removal of Nitrogenous Matters in Sewage Filters.

It was stated in the last report that it was very difficult to obtain satisfactory estimates of the amount of nitrogen stored in the filters from the determination of the material itself, owing to the disturbances, causing unequal distribution, which had been made of the upper layers where the storage is greatest. This difficulty was largely overcome by getting, as an approximate estimate of the stored nitrogen, the difference between the nitrogen of the applied sewage and that of the effluent balance. By this method it is neces-

sary to use several somewhat arbitrary factors in the calculation; and, with a view to obtaining greater accuracy, this subject has received increased attention during the past year.

One of these factors is used in calculating the organic nitrogen from the albuminoid ammonia determination. Throughout these investigations the organic nitrogen has been taken as fourteen-seventeenths of the albuminoid ammonia doubled. This factor of 50 per cent. for the albuminoid ammonia is based on the comparison of numerous results obtained in 1888 to 1890 by the Wanklyn albuminoid ammonia, and the Kjeldahl organic nitrogen, methods, from various substances.

The station sewage of the past year has been found to be somewhat different in composition from that of five years ago, and from the data at hand it appears that the factor for albuminoid ammonia is rather variable, but averages at present about 40 per cent. On page 460 this subject has received some discussion, and it will be remembered that it was stated that many of the earlier analyses were made in the Boston laboratory before the Lawrence laboratory was established, and the increased delay allowing further decomposition is undoubtedly a prominent point to be taken into consideration.

The other important factor of an arbitrary nature is that used to express the loss of nitrogen during the process of nitrification. From accurate determinations of nitrogen in the applied sewage, in the effluents and in the materials themselves made during the earlier years when the upper layers of the filters had not been disturbed, it was learned that this factor ordinarily ranged from 25 to 35 per cent., and averaged about 30 per cent. At the present time the conditions influencing this loss of nitrogen are not clearly understood, although it is known that nitrification causes the escape into the atmosphere of nitrogen gas. The data at hand still go to show that this factor is variable, but indicate that 30 per cent. is a little too high.

Considering these factors together, it appears that both are rather variable, that one is too low, the other too high, and that the errors to a large extent offset each other. In short periods the results obtained by this method of calculation may, perhaps, in a few cases be a little misleading, but from long periods there are strong grounds for believing that they yield a reasonable approximation to the truth.

In the table below are presented results upon the storage of nitro-

gen in the several sewage filters during the year 1894. The method of calculation is the same as that used for the 1893 results; that is, estimates of the storage or removal, taken as the difference between the nitrogen in the plain sewage and that appearing in the effluent including 30 per cent. loss. Bearing in mind the above comments upon this method of calculation, it will be seen that the results confirm, generally, the conclusions drawn in the preceding reports. A summary of our present knowledge upon this subject is deferred until the data of the storage of nitrogen and of fats in the filtering materials themselves have been presented.

Per Cent. of Applied Nitrogen that was stored in the Several Filters, 1894.

Number of Filter.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Average.
1,	−6	−1	−43	−30	−72	−37	−32	−18	12	−8	-	39	−18
2,	9	9	15	−2	−64	−14	−28	55*	−1	22	12	34	+4*
4,	80	77	63	48	35	11	20	17	30	30	7	42	+38
5 A,	12	8	−23	−13	−35	−26	−14	2	−25	9	19	30	−5
6,	10	18	−32	−12	−25	−26	−13	2	−67	47	-	46	−5
7,	5	55	67	24	20	32	−16	-	-	-	-	-	27
9 A,	14	−3	−37	−13	−58	−23	−35	−1	6	14	-	20	−11
10,	-	-	-	-	-	-	7	−5	−4	16	46	11	+12
11 A,	29	25	3	21	55	36	45	55	45	57	57	-	+39
12 A,	−23	5	−27	−51	−6	5	7	7	0	−50	−19	−10	−14
13 A,	−24	−11	−48	22	13	−88	−17	−12	4	9	33	22	−8
14 A,	-	-	-	-	-	−9	−8	18	−6	0	−2	−2	−1
15 B,	45	34	21	53	53	12	4	26	23	34	6	25	+28
16 B,	39	10	39	34	52	22	33	42	20	37	2	31	+30
17 A,	−20	6	−8	−3	−11	−36	−39	0	−5	−2	6	8	−9
19,	−30	−32	−79	−41	−20	−20	−14	4	7	−22	14	−9	−20
21 A,	-	-	31	−4	41	36	13	54	55	0	0	25	+25
22 A,	-	-	39	11	47	68	45	44	32	14	19	27	+35
30,	6	−31	−22	−4	−33	−97	−63	−13	−22	−13	−4	13	−24
31,	10	24	−28	−9	−30	−132	34	-	-	-	-	-	−19
32,	−28	−71	−157	−48	−3	−11	−29	9	2	14	48	1	−23

* See page 493.

Filters Nos. 1, 5 A, 6 and 9 A, which are placed out of doors, each contained less stored organic matter in December than in Janu-

ary. This is confirmed by the results of analyses of the filtering materials themselves. Numerous determinations of the nitrogen in the sands from the different filters have been made, and, while it has been found that the results were quite variable in those cases in which the upper layers of the filter have been recently disturbed, yet series of results show a reasonably close agreement in those instances where there has been no disturbance of the surface layers below the upper inch for a period of six months or more.

In the next table are presented the results, showing the amount of nitrogenous matter stored in Filter No. 1 in October, 1894, compared with that present in the filter in December, 1893, and in March, 1895. From this table it is apparent that the greater part of the organic matter is present in the upper foot of the filtering material, as is also true in the case of the fats. Nevertheless, the storage of nitrogen in the material below the upper foot is a fairly good index to the permanency of the filters.

In the case of Filters Nos. 1 and 9 A there are presented in the table below the amounts of nitrogenous organic matter stored in the lower four feet at different times during the period of their operation. These results confirm those presented in the table on page 488, and show clearly that there has been very little or no increase during the past year in the amount of stored nitrogenous organic matter in these filters.

Table showing the Amount of Nitrogen stored in the Sand of Filter No. 1 at Different Depths, calculated from Albuminoid Ammonia Determinations and Deducting the 0.83 Part of Nitrogen contained in the Original Sand.

[Parts per 100,000 by weight of dry sand.]

Distance below Surface. (Inches.)	December, 1893.	October, 1894.	March, 1895.
1,	142.3	203.4	133.0
3,	74.0	29.5	74.3
6,	45.0	11.5	30.7
9,	39.2	13.9	15.2
12,	34.9	15.0	16.0
18,	24.1	13.8	14.6
24,	15.6	11.8	15.2
36,	10.2	4.9	5.7
48,	5.2	2.5	3.9
60,	4.6	1.8	2.9

Table showing the Amount of Nitrogen stored on Different Dates in the Lower Four Feet of Material in Filters Nos. 1 and 9 A, in Pounds.

Filter No. 1.				Filter No. 9 A.	
Date.	Nitrogen.	Date.	Nitrogen.	Date.	Nitrogen.
Dec., 1888, . .	2.50	Mar., 1891, . .	3.90	Mar., 1891, . .	1.27
Feb., 1889, . .	2.24	June, 1891, . .	3.60	June, 1891, . .	.39
June, 1889, . .	1.30	Nov., 1891, . .	4.90	Nov., 1891, . .	1.50
Nov., 1889, . .	1.50	June, 1892, . .	6.37	Jan., 1894, . .	4.72
Apr., 1890, . .	1.80	Dec., 1892, . .	11.50	Nov., 1894, . .	5.00
June, 1890, . .	1.40	May, 1893, . .	10.40		
Nov., 1890, . .	1.80	Oct., 1894, . .	6.44		

The Storage and Removal of Fats from Filters.

Repeated analyses have been made of the amount of fat stored in Filters Nos. 1, 6 and 9 A. In all cases during the latter part of 1894 the amount of fat as determined by extraction with ether has been found to be considerably less than the amount found in earlier years. As was pointed out in the 1892 report, however, there is a possibility that these matters may have passed into some compound insoluble in ether, and thereby escaped the regular method of determination. The results show a decrease in the amount of fats, not only in the surface layers, but in the lower portions of the filters. The results of these determinations are summarized as follows: —

Filter No. 1. — October, 1894, contained 4 pounds.

Filter No. 6. — March, 1892, contained 14 pounds, of which 3.65 pounds were removed by scraping. September, 1893, removed by scraping 2.75 pounds. October, 1894, contained 2 pounds.

Filter No. 9 A. — January, 1894, contained 14 pounds. November, 1894, contained 11.7 pounds.

These various results confirm conclusions of earlier reports, the two most important of which are as follows: —

1. With the same main body of sand, sewage filters may continue to purify sewage for an indefinite time, provided they receive proper treatment to insure sufficient ventilation for the oxidization and nitrification of the applied organic matters.

2. That the permanency of sewage filters is independent of the size of the filtering material, and is directly dependent upon the treatment which they receive.

Management of Filters to secure their Continuous Efficiency.

Since the treatment which the filters receive is the most important consideration in regard to their permanency, the lessons learned of the different methods of management to secure their continuous efficiency are among the most practical and important results obtained from investigations upon sewage purification. This subject has received especial attention during the past two years. An outline of our present knowledge is as follows: —

Raking.

The accumulation of organic matters at and near the surface of the sewage filters will, after a time, produce serious clogging and deterioration of the qualitative efficiency, unless some preventive measures are adopted. For more than four years it has been the practice to rake the surface to a depth of about one inch once a week; that is, after six days of daily application of sewage. With sewage of the quality of that obtained at the station this systematic raking of the surface has proved very satisfactory, and has been found to be superior to other methods of regular treatment. Similar results can be obtained on a large scale by harrowing. When sewage is applied to filters in large quantities, it is necessary to supplement this method of preventing surface clogging with some occasional further treatment to improve the condition of the layers below that reached by raking. Such treatment is ordinarily best afforded by deeper spading, corresponding to ploughing, as is described beyond.

Scraping.

Under the conditions which exist at the station, the removal, by scraping, of thin layers of material from the surface from time to time has not been found advisable, and the method has been largely abandoned. The chief objection to the method is that it is too expensive for the benefit that is derived from it. After a time the upper portion of a filter which has been systematically scraped becomes so compact that it is necessary to resort to practically the same treatment as is the case when the cheaper method of system-

atic raking has been followed. Owing to the state of decomposition and to other conditions of the sewage pumped at the station, the sludge is in more finely divided particles than in some of the fresher sewages, such as are found in several of the sewage-disposal establishments in the State. With the latter sewages the sludge is deposited to a greater extent upon the surface, and penetrates into the pores of the material to a less extent than at Lawrence. Under these conditions it is certainly advisable to scrape off the surface scum of accumulated sludge, rather than to rake it into the filter. Scraping is also a useful method of treatment in those cases where filters are clogged to the depth of several inches below the surface, and where it is necessary to rejuvenate the filters as quickly as possible. These conditions are likely to occur when the area of the filtering surface is very limited, and particularly under conditions where full benefit cannot be derived from ploughing or resting.

Ploughing.

Whether the method of systematic treatment for the removal of surface clogging is raking or scraping, it has been found that the process of filtration is materially aided by occasional deep spading, corresponding to ploughing. Many of the experimental filters during the past year have been spaded over in this manner in the early spring (April 1) and again in the fall. At all seasons of the year this treatment has the advantage of rendering the filters more porous, thereby increasing ventilation and facilitating the process of oxidation. It may be noted here, however, that in the case of Filter No. 5 A, filled with a sifted gravel and completely under-drained, ploughing causes the sewage to pass through so quickly that full benefit is not derived from the filtration. During the period of most active nitrification (April to October) it is of much assistance in causing the removal of fats and other organic matters from the upper layers of the filtering material.

Resting.

In the annual report of the Board for 1893 it was shown that the clogging in the surface layers of the filter may be materially reduced by resting. This method has been tried upon several of the filters during the past year. The results may be summarized as follows:

1. The organic matter stored in the upper layers of the filters may be largely removed by resting them during the warmer months of the year.

2. The removal is much hastened by ploughing the surface of the filters; in fact, when the clogging is so great as to cause the material to hold itself nearly saturated, resting alone is of little aid.

3. Resting during the winter months effects practically no removal of the organic matter, although it prevents, of course, a further increase.

4. The period of resting should not be too long, particularly during the winter months, when the nitrifying organisms are less active, because there is danger of these organisms dying out, thereby necessitating a period of "biological reconstruction," in which the processes may become re-established. This appears to have been the case with Filters Nos. 1, 6 and 9 A, which were rested during the month of November.

Cropping.

The removal of stored organic matter from the upper layers of filters by means of growing crops has not received, as yet, any especial investigation at the station, but the following observation is of interest in this connection: —

In June wild grass, chiefly *Panicum dichotomum*, appeared upon the surface of Filter No. 2, and grew very luxuriantly during the middle of the summer. The greater part of the growth was at and near the edges of the trenches, where it was very thick. The grass was cut on August 15. At the existing rate of filtration it took the sewage nearly two weeks to pass through the filter of fine sand. Bearing this in mind, and comparing the results of analyses of the effluent in the table beyond, it will be seen that for about two months in midsummer, when the grass was growing on the surface, the nitrates in the effluent gradually decreased, and upon cutting the grass they quickly increased. As there was no clogging or other complication so far as is known, it appears that the equivalent of about half the amount in the applied sewage was utilized for a time by the growing plants.

Table showing Results of Analyses of Effluent of Filter No. 2 before and after cutting the Growth of Grass.

[Parts per 100,000.]

Week Ending. 1894.	Rate of Filtration (Gallons per Acre Daily, Six Days in the Week).	Temperature. (Degrees F.)	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
				Free.	Albuminoid.		Nitrates.	Nitrites.	
July 2, ...	40,000	67	.08	.0016	.0142	8.53	4.58	.0000	.09
17, ...	40,000	69	.05	.0008	.0126	7.72	3.08	.0014	.09
24, ...	40,000	72	.04	.0010	.0140	14.78	2.82	.0000	.06
Aug. 7, ...	40,000	73	.05	.0004	.0112	7.88	1.54	.0000	.11
14, ...	40,000	72	.04	.0010	.0124	7.08	1.37	.0000	.12
21, ...	40,000	70	.04	.0006	.0130	10.01	1.32	.0000	.05
Sept. 4, ...	40,000	70	.04	.0004	.0118	14.09	3.30	.0000	.10
18, ...	40,000	68	.05	.0002	.0104	9.52	4.05	.0000	.10

Application of Sewage to Trenches. — Lateral Filtration.

Filter No. 2. — This filter, of very fine sand, has received sewage in trenches filled with coarse sand, as described in the report for 1893. The trenches were relieved from clogging at the bottom and sides on Dec. 2, 1893, and since that time the filter has given an effluent which regularly improved in quality during the winter, and which has been very satisfactory during the last half of the year. Clogging appeared at the end of November, 1894, at the same place as in the preceding year, and the filter was treated in a similar way in December, 1894. No material has been removed from the filter, which was spaded over, corresponding to ploughing, four inches deep on March 31. The average results for the year indicate a removal of 97 per cent. of organic matter (albuminoid ammonia) and 99.95 per cent. of bacteria from the applied sewage. The average rate of filtration has been 43,900 gallons per acre daily for six days in the week, calculated for the entire area. For the area of the trenches alone this rate is equivalent to 166,000 gallons.

Filter No. 4. — This filter, of very fine river silt, has received sewage in trenches of coarse sand, described in preceding reports. The trenches were raked at the sides and bottom on July 18. The average rate of filtration for the entire area has been 20,100 gallons per acre daily for six days in the week in 1894, and the removal of organic matter (albuminoid ammonia) and of bacteria has been,

respectively, 95 and 99.99 per cent. This filter has contained more and more stored organic matter each year, and it may be safely stated that it would be practically useless as a filter were it not for the trenches. The subject of the application of sewage to filters of fine material, by means of trenches of coarser sand, has received special attention for more than six years.

The results, on the whole, show that this method of treatment has much merit, and our present knowledge concerning it may be summarized as follows: —

1. Both the qualitative and quantitative efficiency of filters of fine material are aided materially by the application of sewage to trenches filled with coarse sand.

2. Ventilation of the main body of the filtering material is increased by the absence of sewage from the surface of the fine material.

3. The application of the sewage to the trenches of coarse sand offers the following advantages: —

(*a*) Less likelihood of the receiving surface becoming frozen.

(*b*) The more ready removal of frost if such occurs.

(*c*) Concentration of heat in the trenches, whereby the biological processes are aided during the winter months.

This latter point is brought out more clearly by the following table of results from Filter No. 2, which has just been described. It may be added here that these results are the most marked example of high nitrification and steady improvement in quality of effluent during the winter months which have been obtained at the station.

Table showing Monthly Averages of Analyses of Effluent of Filter No. 2 during Winter of 1893–94.

[Parts per 100,000.]

Date — 1893-94.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
December,	60,000	45	42	.09	.8480	.0424	7.01	1.68	.3600	.40	2,339
January,	60,000	45	38	.08	.6260	.0332	6.35	2.17	.1060	.28	2,527
February,	54,600	43	36	.06	.1416	.0230	5.76	2.39	.0190	.21	371
March,	57,800	46	39	.06	.1035	.0200	4.90	2.15	.0097	.17	162
April,	40,000	46	43	.06	.0382	.0179	7.04	3.15	.0005	.17	1,075
May,	40,000	57	55	.06	.0025	.0174	6.93	4.29	.0000	.13	2,150

4. The removal of organic matter by growing vegetation upon the finer material between the trenches and where no sewage is applied is a subject worthy of careful consideration.

5. The trenches dispose of the sewage much more readily than might be expected, owing to the fact that the available area for filtration includes not only the bottom but also the sides of the trenches.

Filter No. 10. — This large tank, $\frac{1}{200}$ of an acre in area, was filled in July with 5 feet in depth of coarse and fine sand like that in Filter No. 6, and having an effective size of 0.35 millimeter. No coarse material for under-drains was placed beneath the sand except directly above the outlet. A partition extending 3 feet below the surface was placed in the sand, separating that quarter of the surface which was farthest removed from the under-drain. To this quarter of the surface sewage has been applied, beginning July 18, at the rate of 160,000 gallons per acre daily for six days in the week. The partition causes the sewage to pass downward for 3 feet, and then it has a lateral movement through a distance of 12 to 16 feet. This experiment has not been continued long enough to warrant any marked conclusions, but the results so far as they go are very satisfactory. The removal of organic matter (albuminoid ammonia) and of bacteria from the applied sewage has been 97 per cent. and 99.3 per cent., respectively.

The favorable effect of lateral filtration in trenches, and the high degree of purification of the sewage at Framingham after flowing a long distance through the ground to springs in the meadow, indicate that this lateral filtration is an important feature of sewage purification upon a large scale. This subject has recently received especial attention at the station.

In connection with the subject of management of filters, see the subsequent chapters on the effect of winter weather (page 513) and comparison of conditions of experimental filtration with those in actual practice (page 532).

Summary of Seven Years' Results from Intermittent Out-door Sewage Filters, to show the Average Quantitative and Qualitative Efficiency of Experimental Filtration.

The summary includes the results from those out-door filters which have continued in operation during the past year. Some of the early filters, the results of which do not appear, were for the most part constructed of loam, peat or such materials as were found to be useless for filtering purposes. To bring out the work of the filters more clearly, the yearly averages of the analyses of the several effluents and rates of filtration are presented, together with an outline of the most important features in the operation of each filter. Beyond this is a table summarizing the results of the work of these experimental filters from the beginning of the investigations up to Jan. 1, 1895, as well as a brief review of the general condition which existed during the entire period.

Filter No. 1.

This filter was constructed of 63 inches in depth of sand of the effective size of 0.48 millimeter.

1888. — Jan.	10.	Sewage first applied.
Feb.	17.	Trench 18 inches wide and 12 inches from the edge of the tank cut through the ice, and reaching into the sand 2 inches.
Nov.	1.	Tufts of grass pulled up, and one-half of the surface levelled.
Nov.	22.	Surface of the filter covered with canvas.*
1889. — March	13.	Canvas cover removed.
June	29.	Grass cut.
Aug.	6.	Grass again cut.
Nov.	26.	Grass and weeds pulled up.
Nov.	27.	Surface spaded over 4 inches in depth.
Nov	27.	Surface was covered with canvas.
1890. — April	8.	Canvas cover removed.
April	8.	Surface raked 1 inch in depth.
April	18.	Surface raked 1 inch in depth.
June	12.	Surface raked 1 inch in depth.
June	29.	Beginning at this time, surface raked to a depth of 1 inch once a week.
1891. — June	30.	Surface made into ridges and trenches; trenches raked 1 inch deep weekly.
Oct.	13.	Position of ridges and trenches changed.
Oct. 31 to June 2, 1892.		Surface of trenches was scraped and the material removed placed upon the ridges eleven times, total depth of 8 inches.

* The canvas covers were in all cases stretched on a wooden framework so as to allow room beneath the canvas for the distribution of sewage and treatment of surface of the filters.

Filter No. 1 — Concluded.

1892. — June 2. Five inches of sand removed from the surface; surface levelled.
Oct. 18. Surface raked to a depth of 2 inches.
1893. — May 5. Four inches of sand scraped from the surface.
May 11. Nine inches of new sand put on to bring up the filter to its original height.
Dec. 2. Six inches of sand taken off, next 6 inches spaded over, and the upper 6 inches replaced and mixed with the sand below.
1894. — March 31. Surface spaded over to a depth of 4 inches.
Oct. 13 to 27. No sewage applied.
Nov. 5 to 30. No sewage applied.
Nov. 5. Surface spaded over to a depth of 8 inches.
Nov. 17. Surface spaded over to a depth of 8 inches.

Table of Yearly Averages of Analyses of Effluent of Filter No. 1.

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1888, . . .	53,400	52	.1823	.0277	4.97	.8000	.0031	1.00	–	14,814
1889, . . .	63,600	54	.0639	.0283	4.64	1.4960	.0017	1.60	–	1,878
1890, . . .	84,200	53	.1362	.0392	5.92	1.3572	.0039	1.58	.30	15,877
1891, . . .	115,800	53	.2367	.0490	7.57	1.3022	.0222	1.60	.39	20,000
1892, . . .	124,100	54	.3092	.0757	8.32	1.5237	.0212	1.92	.54	55,992
1893, . . .	105,900	53	.5682	.0965	7.21	2.1269	.0238	2.76	.65	99,362
1894, . . .	70,300	55	.4719	.0674	9.33	3.1200	.0608	3.68	.45	73,800
Final average, .	88,200	53	.2812	.0548	6.85	1.6751	.0181	2.02	.47	40,246

Filter No. 2.

This filter was constructed in 1887 of 60 inches in depth of fine sand, having an effective size of 0.08 millimeter.

1887. — Dec. 19. Sewage first applied.
1888. — Jan. 11. Two trenches 18 and 6 inches, respectively, from the edge of the tank were dug into the material 1 foot wide, 1 foot deep and filled with Filter No. 1 sand.
Jan. 23 to Feb. 16. Sewage entered the material through holes in the sand.
Feb. 17 to March 31. Heated sewage applied.
Nov. 22. Canvas cover put over the surface.
1889. — March 13. Canvas cover removed.
Sept. 26. Grass cut over one-half the surface.
Nov. 26. Grass and weeds pulled up.
Nov. 27. Surface spaded 4 inches in depth.
Nov. 27. Canvas cover put over surface.
1890. — March 3. Surface raked 1 inch in depth.

Filter No. 2 — Concluded.

1890. — April 8. Canvas cover removed, surface raked 1 inch in depth.
June 26. Beginning at this time, surface raked 1 inch in depth each week
1891. — May 1. Surface spaded over 4 inches in depth.
June 1. Surface spaded over 6 inches in depth.
July 25. Surface trenched and ridged.
Oct. 31 to April 11, 1892. Two and five-tenths inches of material scraped from the trenches and the material placed on the ridges.
1892. — Jan. 6. Canvas cover put over the surface.
April 1. Canvas cover removed.
May 31. Ridges and trenches levelled.
Sept. 13. Grass cut.
Nov. 29. Surface protected by canvas cover.
1893. — March 4. Canvas cover removed.
March 4. Two trenches were constructed like those dug in the material June 11, 1888, and each filled with Filter No. 9 sand.
March 4 to April 1. Trenches covered with boards.
July 20. Grass and weeds cut.
Aug. 31. Grass and weeds cut.
Oct. 30. Two inches of sand in trenches removed and replaced with fresh material.
Dec. 2. Trenches taken out, fine sand scraped at the sides and the bottoms of the trenches, and coarse sand replaced after mixing it with fine sand at the junction of the two materials.
Dec. 4. Trenches covered with boards.
1894. — March 17. Boards removed from the trenches.
March 31. Surface spaded over, corresponding to ploughing, to a depth of 4 inches.
Aug. 15. Grass cut.
Nov. 30. Material in trenches taken out and fine sand scraped, material replaced.

Table of Yearly Averages of Analyses of Effluent of Filter No. 2.

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
1888, . . .	28,200	51	.1825	.0129	4.85	.6630	.0168	.85	–	1,346
1889, . . .	32,000	53	.0063	.0089	4.91	1.1010	.0045	1.13	–	49
1890, . . .	59,600	53	.0083	.0102	5.44	1.6250	.0003	1.65	.09	102
1891, . . .	50,800	53	.3141	.0258	7.59	1.0461	.0083	1.35	.22	93
1892, . . .	24,500	53	.5768	.0283	8.03	1.4445	.0070	1.97	.23	32
1893, . . .	40,300	51	.2815	.0233	7.03	2.4070	.0569	2.73	.19	2,116
1894, . . .	43,900	53	.1039	.0173	7.92	2.8500	.0138	2.98	.15	630
Final average, .	39,900	52	.2105	.0181	6.54	1.5909	.0154	1.84	.17	624

Filter No. 4.

This filter was constructed of 60 inches in depth of fine sand of an effective size of 0.04 millimeter, and contains two trenches of coarse sand of effective size of 0.48 millimeter.

1887. — Dec. 19. Sewage first applied to this filter.
1888. — Jan. 23. Two holes cut through the frost in the upper layers of the material.
Jan. 28. Two holes cut through the frost in the upper layers of the material.
Feb. 6. Five holes cut through the frost.
Feb. 7. One hole cut through the frost.
Feb. 17. Trench 18 inches from the edge cut through the ice and 2 inches into the sand.
Nov. 22. Tank covered with boards.
Dec. 5. Boards removed and surface covered with canvas.
1889. — March 13. Canvas cover removed.
June 24. Weeds and grass removed.
June 24. Surface of outer trench of coarse sand removed and replaced by fresh sand; surface left 3 inches below that of the rest of the filter.
Oct. 26. Grass cut on one-half of the surface.
Nov. 15 Grass on the coarse sand pulled up.
Nov. 27. Surface covered with canvas.
1890. — Feb. 18. Surface of coarse sand raked and levelled.
April 8. Canvas removed.
June 4. Surface of coarse sand raked 1 inch in depth each week from this time.
Oct. 27. Grass on fine sand cut.
1891. —
1892. — Feb. 11. Boards put over trenches.
March 30. Boards removed.
April 4. One-half inch of sand removed from the surface of outer trench.
May 9. One inch of sand removed from the surface of outer trench.
July 13 to Aug. 5. No sewage applied.
July 27. Grass cut.
Nov. 29. Surface protected by canvas cover.
1893. — March 6. Two inches of discolored clogged sand removed from the surface of the outer trench.
March 11. Coarse sand taken out and replaced after scraping oft one-half inch of the fine sand at the junction of the two materials.
March 11. Canvas cover removed.
May 6. Turf removed from surface of the fine sand between the edge of the tank and the outer trench.
June 2. An inner trench, 1 foot inside of the outer trench, was dug 1 foot wide and 2 feet deep.

Filter No. 4 — Concluded.

1893. — July 31. Entire surface raked over.
Aug. 31. Grass and weeds cut.
Dec. 4. Trenches covered with boards.
1894. — Jan. 22. Trenches spaded over to a depth of 6 inches.
March 17. Boards removed from trenches.
April 2. Entire surface spaded over, corresponding to ploughing, to a depth of 4 inches.
July 18. Sand removed from trenches, sides and bottom scraped and raked, and coarse sand replaced.

Table of Yearly Averages of Analyses of Effluent of Filter No. 4.

[Parts per 100,000.]

YEAR.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	AMMONIA.		Chlorine.	NITROGEN AS		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
1888, . . .	28,700	51	.3102	.0348	4.62	.2200	.0020	.53	-	803
1889, . . .	20,000	53	.0104	.0122	4.29	.6420	.0002	.67	-	36
1890, . . .	33,200	52	.0018	.0125	6.00	1.2660	.0000	1.25	.14	294
1891, . . .	41,400	52	.0581	.0153	5.62	1.4475	.0008	1.52	.17	50
1892, . . .	41,800	53	.5226	.0542	6.95	.6807	.0027	1.20	.79	94
1893, . . .	32,300	52	.0891	.0313	6.61	1.4536	.0034	1.58	.35	43
1894, . . .	20,100	54	.4786	.0330	7.85	1.5242	.0061	1.98	.42	119
Final average, .	31,070	52	.2101	.0276	5.99	1.0363	.0022	1.25	.37	206

Filter No. 5 A.

This filter was constructed in September, 1891, and contained 60 inches in depth of fine sifted gravel of an effective size of 1.40 millimeters.

1891. — Sept. 14. First sewage applied, surface raked 1 inch in depth each week.
1892. — March 29. Three inches of material removed from the surface, and for the purpose of special experiments replaced successively by 1 inch of Filter No. 1 sand, 1 inch of Filter No. 9 sand and 1 inch of Filter No. 1 sand.
May 20 to June 2. No sewage applied.
June 2. Upper 2 inches removed and replaced by 2 inches of Filter No. 9 sand.
Oct. 19 to Nov. 6. No sewage applied.
Oct. 31. Layer 2 inches in depth of fine sand removed.
Nov. 4. Layer 1 inch in depth (last) of coarse sand removed.

Filter No. 5 A — Concluded.

1893. — June 12. Raked to a depth of 2 inches.
Sept. 15. Spaded over, corresponding to ploughing, to a depth of 6 inches.
Dec. 2. Two inches of material scraped from the surface, which was then spaded over, corresponding to ploughing, to a depth of 6 inches.
1894. — March 31. Spaded over, corresponding to ploughing, to a depth of 4 inches.
April 9. Restored to its original depth, and new and old material mixed together at the junction.
July 13. Spaded over, corresponding to ploughing, to a depth of 4 inches.
Sept. 4. Spaded over, corresponding to ploughing, to a depth of 12 inches.
Dec. 1. Spaded over, corresponding to ploughing, to a depth of 6 inches.

Table of Yearly Averages of Analyses of Effluent of Filter No. 5 A.

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
1891, . . .	64,000	53	.3318	.0418	7.48	.8700	.0116	1.22	.32	99,090
1892, . . .	94,400	54	.8150	.0930	8.65	1.1384	.0278	1.99	.69	99,090
1893, . . .	119,200	53	.5843	.1266	7.57	1.8203	.0133	2.52	.72	214,102
1894, . . .	90,600	54	.6474	.0878	9.11	2.6700	.0382	3.38	.56	105,700
Final average, .	98,100	53	.6515	.0971	8.36	1.7880	.0251	2.28	.63	139,600

Filter No. 6.

This filter was constructed in 1887 of 44 inches of mixed coarse and fine sand, having an effective size of 0.35 millimeter.

1888. — Jan. 12. First sewage applied.
Jan. 23 to March 14. Frost interfered with filtration, and sewage applied in holes dug in the surface.
Nov. 22. Surface protected by canvas cover.
1889. — March 13. Canvas cover removed.
Oct. 26. Grass cut from one-half of surface.
Nov. 26. Surface protected by canvas cover.

Filter No. 6 — Concluded.

1890. — April 8. Canvas cover removed.
Oct. 27. Grass cut from surface.
Dec. 23. Surface raked to a depth of 1 inch.
1891. — Jan. 1. Beginning at this date, surface was raked to a depth of 1 inch weekly.
1892. — March 29. Two inches of material was scraped from the surface.
April 2. Material removed by scraping replaced by fresh sand.
April 11. Surface spaded over, corresponding to ploughing, to a depth of 6 inches.
May 19. Upper foot of sand removed, second foot spaded over, and upper foot replaced.
1893. — Sept. 25. About 2 inches of clogged material scraped from the surface and replaced with fresh material.
Dec. 2. Surface spaded over 6 inches deep.
Dec. 4. Canvas cover put on.
1894. — March 17. Canvas cover removed.
March 31. Surface spaded over 4 inches deep.
Sept. 21 to Oct. 8. No sewage applied.
Oct. 30 to Nov. 30. No sewage applied.
Nov. 8. Surface spaded over 8 inches deep.
Nov. 17. Surface spaded over 8 inches deep.

Table of Yearly Averages of Analyses of Effluent of Filter No. 6.

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
1888, . . .	39,500	52	.0905	.0130	4.71	.7050	.0020	.80	-	3,033
1889, . . .	41,000	53	.0063	.0095	4.60	1.4204	.0004	1.44	-	520
1890, . . .	55,200	52	.0096	.0179	5.45	1.2349	.0005	1.27	.10	7,969
1891, . . .	61,200	52	.1725	.0302	7.30	1.3363	.0027	1.53	.26	6,473
1892, . . .	46,900	54	.7055	.0437	8.42	1.6170	.0320	2.23	.40	6,911
1893, . . .	85,500	53	.4820	.0610	7.39	2.1896	.0996	2.78	.42	11,790
1894, . . .	54,300	55	.1780	.0473	9.80	2.9800	.0982	2.30	.43	10,730
Final average, .	54,800	53	.2349	.0318	6.81	1.6405	.0336	1.77	.32	6,890

Filter No. 7.

This filter was constructed in 1887 and contained 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter, above which was 10 inches of yellow loam and 6 inches of brown loam.

1888. — Jan. 12. Two trenches dug in the loam, filled with coarse sand.
Jan. 14. First sewage applied.
Jan. 14 to Feb. 6. Sewage applied through four holes picked in the coarse material.
Feb. 18. Two inches of sand removed from trenches.
July 25. Five-tenths of an inch of material scraped from the surface of the fine loam.
Nov. 22. Surface protected by a canvas cover.
1889. — March 13. Canvas cover removed.
June 25. A circular trench dug 3.5 feet deep and 2 feet wide, and coarse gravel and stones placed in it. An open-jointed pipe 6 inches in diameter was also laid in this trench 18 inches in depth from the surface; sewage was applied to the drain connected with this sub-surface pipe.
1890. — Surface of the material covered with a scattering growth of grass and weeds from May to October.
1891. — July 13. Grass cut.
1892. — Aug. 4 to Oct. 6. Sub-surface pipe clogged, no sewage applied.
Oct. 7. Pipe taken up, cleaned and re-laid.
1893. — April 26. Sub-surface pipe taken up, cleaned and re-laid.
1894. — July 5. Experiment discontinued.

Table of Yearly Averages of Analyses of Effluent of Filter No. 7.

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1888, . . .	24,500	51	.1227	.0112	4.65	.3800	.0059	.50	–	3,000
1889, . . .	16,100	54	.0012	.0075	4.37	1.3045	.0001	1.32	–	433
1890, . . .	30,500	53	.0191	.0115	5.44	.9821	.0010	1.02	.09	341
1891, . . .	26,700	54	.4885	.0192	6.71	1.6665	.0059	2.11	.15	423
1892, . . .	20,100	53	.0953	.0136	7.68	1.6678	.0059	1.77	.14	1,831
1893, . . .	26,600	53	.9814	.0572	6.81	1.8957	.0253	2.82	.53	1,829
1894, . . .	13,800	53	.0305	.0103	6.73	2.1640	.0009	2.21	.11	57
Final average, .	22,600	53	.2484	.0186	6.06	1.4372	.0060	1.68	.20	1,130

Filter No. 9 A.

This filter was constructed in October, 1890, and contained 60 inches in depth of medium fine sand, having an effective size of 0.17 millimeter.

1890. — Nov. 18. Sewage first applied, surface raked to a depth of 1 inch each week.

1891. — Aug. 31. Surface spaded over, corresponding to ploughing, to a depth of 4 inches.

Oct 19. Surface spaded over, corresponding to ploughing, to a depth of 4 inches.

Nov. 5. Surface made into ridges and trenches.

Nov. 9. Twenty-five one-hundredths of an inch of sand from the trenches removed and put upon the ridges.

1892. — Jan. 1. One inch of sand taken from trenches.

Feb. 11. Surface protected by canvas cover.

April 1. Canvas cover removed.

May 6 to 25. No sewage applied.

May 10. Surface levelled, 6 inches of sand removed, and stratified layers removed.

July 18. Raking of the surface discontinued, and surface scraped when necessary to relieve clogging.

Sept 9. Scum scraped from the surface.

Sept. 20. Scraped 0.40 of an inch of material from the surface.

Oct 7. Scraped 0.53 of an inch from the surface.

Oct. 20 to 31. No sewage applied.

Nov. 9. Scraped 0.53 of an inch from the surface.

Nov. 29. Surface protected by canvas cover.

1893. — Jan. 1 to Nov. 16. Surface scraped nine times, 4 inches of material removed.

March 7. Canvas cover removed.

March 14. Filter filled to original depth.

July 13. Weeds cut.

July 31. Weeds pulled up.

Sept. 25. Filter filled to original depth.

Nov. 16 to 22. Four and five-tenths inches of material scraped off. This was not clogged with organic matters, but was very compact.

Dec. 2. Sand removed from November 16 to 22, replaced with enough new sand to bring up the filter to the original depth.

1894. — Feb. 1. Scraping discontinued, and weekly raking to a depth of 1 inch resumed.

March 31. Surface spaded over, corresponding to ploughing, to a depth of 4 inches.

Oct. 13 to 28. No sewage applied.

Nov. 3 to 28. No sewage applied.

Nov. 5. Surface spaded over, corresponding to ploughing, to a depth of 8 inches.

Nov. 17. Surface spaded over, corresponding to ploughing, to a depth of 8 inches.

Table of Yearly Averages of Analyses of Effluent of Filter No. 9 A.

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily far Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
1890,* . . .	110,000	-	.8275	.0450	5.37	.0711	.0037	.83	.16	4,685
1891, . . .	95,800	52	.5094	.0240	8.26	1.3272	.0093	1.79	.22	676
1892, . . .	68,100	54	.6470	.0384	8.46	1.3208	.0123	1.93	.36	2,401
1893, . . .	111,700	53	.7244	.0598	7.52	1.9551	.0047	2.65	.40	13,367
1894, . . .	68,800	54	.5252	.0432	8.14	2.9000	.0079	3.41	.31	14,030
Final average, .	86,500	53	.5967	.0415	8.02	1.8252	.0084	2.12	.32	7,536

* November 18 to December 31.

The yearly averages of analyses of the station sewage have been tabulated and discussed on page 456. Those results showed that during the latter part of the period covered by these investigations, the sewage has been much stronger than formerly. This fact is also shown by the results of the analyses of the effluents, which have latterly contained much larger amounts of chlorine and of nitrogen, in the form of nitrates.

With regard to the general character of the effluents, it is desired to call attention at this time to two principal points, as follows: —

1. The quality of the effluents, as indicated by the free and albuminoid ammonia and the oxygen consumed, has been less satisfactory during the past four years than it was prior to 1891.

2. During 1894 the quality of each of the effluents, with the exception of that of Filter No. 4, has been better than it was during the preceding year.

Adding to the second one of the above-mentioned facts, the information which was presented on storage of nitrogenous matter and fats, under the question of "permanency of filters," it is clear enough, after seven years' experience with intermittent sewage filters, that there is no ground for the belief that the usefulness of sand filters in the purification of sewage becomes more and more limited as they continue in service. As has been noted in this and earlier reports, intermittent sewage filters will continue to do good work for an

indefinite time, provided they receive proper management. But the question may arise, How is it that there has been such a deterioration in the quality of the sewage effluents during the past few years? In answer to this it may be said that the conditions of operation of the experimental filters have been different; and so far as is known this is a full explanation of the differences in the analytical results presented in the tables on the foregoing pages.

Some of the changes in conditions were not anticipated, but a majority of them were purposely made and maintained for the sake of learning what results would be obtained under certain circumstances which would probably arise in actual practice. One of the results of experimentation along these lines was the fact that the effluents have suffered deterioration in quality, but another and more important result is the information which has been obtained concerning the effect arising from certain causes, and which serves as a guide whereby the Board may advise the local authorities in Massachusetts with regard to the best methods of sewage disposal. These various factors and their results have been considered in detail in earlier reports of the Board, but at this time, when we are considering the work of the filters for the entire period of the investigations, it will be worth while to briefly note some of the conditions which have influenced the results under our present consideration.

Brief Review of Prominent Factors in the Operation of the Experimental Sewage Filters, 1888–94.

During the first winter of operation (1887–88) when the filters were new and unprotected from the weather, nitrification did not become readily established until warmer weather began. With moderate rates of filtration and with comparatively dilute sewage, excellent results were obtained during the latter part of 1888; and the results continued to be very satisfactory under these conditions through the winters of 1888–89 and 1889–90, by the aid of canvas covers to protect the filters from cold weather.

Beginning in the early part of 1890, some difficulty was encountered with the scum which had accumulated on the surface of the filters from the sludge of the applied sewage. In the spring of this year, the marked advantage of raking the surface weekly to a depth of 1 inch was learned. Excellent results with regard to

quality of effluent were obtained during the summer of 1890, and the rates of filtration were increased in order to learn the capacity of the filters under this improved surface treatment.

The condition of the filters in the fall of 1890 was so satisfactory as to warrant a departure from the practice of the two preceding winters, and continue the operation of the filters through the winter with the surfaces unprotected from the weather. Some very instructive results were obtained, showing that while the cold weather interfered considerably with the completeness of the purification, yet the filters yielded effluents superior in quality to that obtained by any other method for the purification of sewage. It is true that in some instances there were obtained at this time effluents of which the quality was such as to render it questionable whether they could be turned into drinking water streams with safety. Another and very serious result of operation of the filters under these conditions was the fact that a considerable portion of the organic matter of the applied sewage remained stored in the filtering material and was removed with difficulty after the winter was over.

During the early part of 1891, the increased concentration of the applied sewage became quite marked, owing largely to the number of new connections which were made with the sewer. With the high rates of filtration, increased strength of applied sewage and storage of organic matters in the filters during the preceding winter, it was learned in the spring of 1891 that the customary weekly raking of the surface to a depth of 1 inch was insufficient to insure the entrance into the pores of the filters of an adequate amount of air. With the view to increase the ventilation of the filters, the surfaces in some instances were arranged in the form of ridges and trenches. This did not seem to furnish either a marked or a permanent relief, however, and the quality of the effluents during the summer and fall of 1891 was inferior to that obtained during corresponding seasons of the preceding years.

Most of the out-door filters were considerably clogged at the beginning of the winter of 1891–92, which was unusually mild for this climate. About half of the filters were protected from the weather by canvas covers. The chief characteristic of the results obtained during this winter was the small amount of nitrates present in the effluents, thereby indicating a marked storage of organic matter within the filtering materials.

In the spring of 1892 a careful study was made of the filters, and it was learned that not only did clogging come from the surface layers, but also from the presence, in a majority of the filters, of "stratified layers" caused by throwing the material into water when the filters were first constructed, as explained in detail in the annual report of the Board for 1892. One of the marked effects of these layers from a practical point of view was that they excluded air from layers beneath them. This difficulty was remedied in the most marked instances by taking out the filtering materials and replacing them in the tanks when dry.

During 1892 the sewage became somewhat stronger, but the high rates of filtration were still continued, as much benefit was derived from the treatment noted in the last paragraph. With regard to the quality of the effluents, in some cases there was an improvement, but in most cases there was a deterioration when compared with the results of the preceding year. In no instances, however, was the character of the effluents of the high grade which was obtained during the first two or three years of the investigations.

One of the results of the above-mentioned disturbance of the materials was that the filters were more porous for a time than was formerly the case. In consequence of this, the sewage disappeared more promptly, and nitrification improved. At the beginning of the winter of 1892–93, the filters were in fair condition, — considerably better on the whole than at the beginning of the preceding winter. About half of the filters were protected from the cold. The storage of organic matter in the filters was less than during the winter of 1891–92. Nevertheless, the nitrification became very incomplete before the winter was over, in the case of nearly all of the filters, and the amount of organic matter and free ammonia in the effluents was unsatisfactory.

In the spring of 1893 it became evident that while effluents were obtained which were of greater purity than was the case with chemical precipitation or any other method for the purification of sewage, yet some radical change in the treatment of the filters was necessary in order to obtain satisfactory effluents. There were two leading factors which came up for discussion: first, the removal of the surface layers which had become clogged through overdosing; and, second, the reduction

of the quantity of applied sewage, which was gradually becoming stronger.

It was decided to deal with one factor at a time, and the surfaces of the filters were spaded and scraped as described in the report of the Board for 1893. The result of this treatment was that nitrification became the highest in the history of the investigation up to that time, and the organic matter stored in the filtering materials was removed to a marked degree. The quality of the effluents during the spring, summer and fall of 1893 was better, on an average, than had been the case since the summer of 1890, when the high rates of filtration were first adopted.

The rainfall during the autumn of 1893 was unusually light, and the sewage became exceptionally concentrated at this time. This seemed to be a factor in causing less complete nitrification, although the chief reason doubtless lay in the insufficient aeration, owing to the sub-surface clogging. The difficulty arising from the presence in the filters of adjoining layers of unlike material was effectively remedied Dec. 2, 1893. But, as was afterwards learned, the remedy came too late to allow nitrification to become well established before severe winter weather set in.

As a result of the above treatment the filters were more porous, and during the winter of 1893–94 disposed of the usual amount of strong sewage without difficulty, even when unprotected from the cold. Nitrification was greater than during any preceding winter, but the effluents, owing to the cause noted above, contained more organic matter than was desirable.

In the spring of 1894 it was decided to reduce the quantity of applied sewage which still grew stronger. Accordingly the rates of filtration in most cases were reduced by about one-third on April 1, 1894. The object of this decrease in quantity of sewage treated by the filters was of course to insure a gain in the quality of the effluents. During the warmer months of 1894 the character of the effluents, on the whole, was very satisfactory, and in the case of some filters the effluent was the best which had been obtained up to that time.

In the fall of 1894 it was the purpose to remove from the filters by nitrification as much of the stored organic matter as possible, and to have the process of nitrification in excellent condition at the beginning of cold weather. With this end in view, Filters Nos. 1, 6 and 9 A were spaded over, corresponding to plough-

ing, and allowed to rest for about one month as has been already noted. Cold weather began early in November, and the result of this treatment was that the activity of the organisms of nitrification was lessened. While it is true that this experience led to a negative result with regard to the problem which it was intended to solve, nevertheless, from a practical point of view, it is one of much importance.

Comparison of the Influence exerted upon the Results of Filtration by these Various Factors in Winter and Summer, respectively.

From the detailed accounts of the work of the several filters, year by year, as well as from the brief historical review which has just been presented, it is clear that the effect of unfavorable conditions upon the purification of sewage by filtration is most marked, as a general rule, during the winter months. In order to bring out this idea more sharply the final average results from the various filters are given in the following table, and in the second table beyond these results are divided into two periods, namely, summer and winter. These divisions are somewhat arbitrary, and include the months of May to October, and of November to April, respectively. This was done largely for the sake of uniformity and clearness, as will be explained subsequently, and it is not to be supposed that actual winter weather in Massachusetts continues for a period of six months.

Summary of the Average Results of Seven Years' Analyses of Effluents of Filters Nos. 1–9 A.

[Parts per 100,000.]

Number of Filter.	Period.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Free.	Albuminoid.		Nitrates.	Nitrites.			
1, . . .	1888-94	88,200	53	.2812	.0548	6.85	1.6751	.0181	2.02	.47	40,246
2, . . .	1888-94	39,900	52	.2105	.0181	6.54	1.5909	.0154	1.84	.17	624
4, . . .	1888-94	31,100	52	.2101	.0276	5.99	1.0363	.0022	1.25	.37	206
5 A, . .	1891-94	98,100	53	.6515	.0971	8.36	1.7880	.0251	2.28	.63	139,600
6, . . .	1888-94	54,800	53	.2349	.0318	6.81	1.6405	.0336	1.77	.32	68,900
7, . . .	1888-94	22,600	53	.2484	.0186	6.06	1.4372	.0060	1.68	.20	1,130
9 A, . .	1890-94	86,500	53	.5967	.0415	8.02	1.8252	.0084	2.12	.32	7,536

Summary of Entire Results of Analyses of Effluents of Filters Nos. 1–9 A up to Nov. 1, 1894, in Six Month Periods, to show the Effect of Winter Weather.

Filter No. 1.

[Parts per 100,000.]

Season.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature — Deg. F.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Winters, . .	87,000	42	.4754	.0701	5.37	1.1200	.0276	1.62	.67	54,500
Summers, . .	90,000	65	.0794	.0383	7.98	2.1200	.0098	2.23	.34	27,000

Filter No. 2.

Winters, . .	39,600	41	.1993	.0181	4.88	1.0400	.0185	1.22	.20	1,280
Summers, . .	42,200	63	.2270	.0170	7.82	2.0300	.0086	2.25	.17	141

Filter No. 4.

Winters, . .	33,900	42	.1054	.0215	5.13	.7700	.0007	.89	.29	418
Summers, . .	28,700	63	.3231	.0342	6.87	1.1700	.0037	1.50	.35	104

Filter No. 5 A.

Winters, . .	99,700	41	.8176	.1327	6.93	1.5800	.0333	2.50	.79	235,200
Summers, . .	90,800	66	.3970	.0671	9.79	2.1200	.0151	2.57	.48	84,200

Filter No. 6.

Winters, . .	48,400	41	.3853	.0394	5.19	1.0000	.0502	1.43	.48	11,800
Summers, . .	57,100	64	.0700	.0226	8.09	2.2000	.0115	2.30	.21	5,500

Filter No. 7.

Winters, . .	26,400	42	.3173	.0197	4.83	.9100	.0027	1.50	.15	2,160
Summers, . .	23,300	64	.1528	.0180	7.38	2.0900	.0108	2.26	.12	577

Filter No. 9 A.

Winters, . .	80,800	41	.6165	.0587	6.27	.9400	.0077	1.55	.43	11,932
Summers, . .	95,700	66	.0691	.0200	9.43	2.6600	.0083	2.76	.17	890

These analytical results show that during the summer months the effluents have contained in each case larger quantities of nitrates and fewer bacteria than during the winter months. Again, if we except Filters Nos. 2 and 4, of very fine sand, the effluents have contained

in summer the least free ammonia and organic matter as indicated by the albuminoid ammonia and oxygen consumed. The reasons why Filters Nos. 2 and 4 have behaved differently than the other filters are explained in the following chapter, in which is given a detailed discussion of the most important factors that have exerted an influence upon the results of filtration. The present chapter, in which considerable material is presented in a convenient form for reference, may serve as an introduction to the one following.

Detailed Account of Factors which have exerted an Influence on the Purification of Sewage by Experimental Intermittent Filtration, with Especial Reference to Winter Weather in Massachusetts, and Reasons why the Results of 1888–89 were better than those of Recent Winters.

From the summary of results in the last chapter it is plain that the quality of the effluents has deteriorated at times during the latter portion of the investigations. The last table made it clear, also, that in most instances it has been during the colder months of the year that this deterioration has been most noticeable. Partly with the view to aid in learning what is the best management of filters under these circumstances, and partly to place on record for convenient use an analysis of the more prominent factors, a detailed study has been made of the conditions which exert an influence upon the purification of sewage at this season of the year.

In order to make this study more complete, and to show the influence of the various factors during the several winters, there are given in the set of tables beyond each year's results from the effluents of the several filters in six month periods up to Nov. 1, 1894. Many of the earlier results have been similarly presented on former occasions in order to show the effect of overdosing, stratification, etc., and the influence of these conditions has been discussed in earlier reports and is very briefly referred to in the preceding chapter of this volume.

Final averages of the analytical results arranged in six month periods have been presented on page 512. As an introduction to that table it was explained that the results of analyses are divided into two periods, namely, the summer period, May to October, inclusive, and the winter period, November to April, inclusive, largely on the ground of uniformity and clearness.

Owing to the fact that different filters behave very differently under the influence of certain disturbing influences, it was apparent that the winter period must be of sufficient length to include the deteriorating results from filters of coarse material, which may feel the effect of winter weather late in November; and also those from the finer filters, which may not show the effect of winter weather until early spring, but which require fully as long a period as the filters of coarse material in order to again attain their normal efficiency. This is a matter of sufficient importance from a practical point of view to be made the subject of the following special discussion, which will make plainer the results in the tables which follow it.

Differences in the Behavior of Filters of Fine Material and those of Coarse Material, especially in Winter Weather.

Owing to greater capillarity, filters of fine material retain much larger quantities of sewage in their pores than is the case with filters of coarse material. Thus, for example, Filters Nos. 1 and 4 when new held in their pores, after having been filled with water and allowed to drain for twenty-four hours, about 1,000 and 2,500 gallons, respectively. With recent rates of filtration this means that with Filter No. 1 the sewage on an average has remained in the pores of the material for about two days, while for Filter No. 4 this period is about four weeks.

The practical result of this is that the filters of coarse material show the effect of winter weather, under unfavorable conditions for filtration, in a very short time, — frequently during the latter part of November, — while with other conditions equal, it is several weeks usually in the case of fine filters before the effluent shows deterioration; and even then the change in character of the effluent is confined largely to a diminution of nitrogen in the form of nitrates, while the organic matter will still be very low for some time, owing, apparently, to an unusual power possessed by certain fine sands to retain and store soluble organic matters and free ammonia. Another point worth mentioning is that the analyses of effluents of filters of coarse material are a ready guide for their management, while for fine filters this is less true on account of the slow passage of sewage through them. In fact, with fine filters it is many times the case that surface clogging is the first indication of unsatisfactory work.

With regard to the restoration to normal work there is a marked difference in the action of filters of coarse and of fine materials.

Coarse filters, which contain sufficient air in their pores, usually begin to recover rapidly from the effects of winter weather about March 1. At this time fine filters in some instances are just beginning to yield an effluent containing an abnormal amount of free ammonia and organic matter. The time during which they may continue to do unsatisfactory work is more extended than in the case of coarse filters, owing partly to the greater amount of water held in the pores of the filter, and consequently a less prompt remedy of the existing difficulty. There are other factors which prolong this period; they are not all clearly understood, but a point well worth mentioning is that it appears to be more difficult to re-establish the process of nitrification in material that holds itself saturated, or nearly so, than in the case of coarser material, where there is more opportunity for aeration.

These explanations will make it clear why the free ammonia and organic matter are shown by the following tables of analyses to have been higher during the summer than during the winter period.

Table showing Average Results of Analyses of Effluent of Filter No. 1, by Six Month Periods.

[Parts per 100,000.]

Period.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Jan.-April, 1888, . .	36,000	38	.4227	.0390	2.45	.1100	.0015	.52	-	40,310
May-Oct., 1888, . .	60,000	64	.0418	.0198	6.41	1.2100	.0039	1.28	-	2,266
Nov., 1888-April, 1889, .	69,000	47	.0912	.0268	4.85	1.1300	.0018	1.25	-	2,288
May-Oct., 1889, . .	65,000	65	.0423	.0277	4.97	1.8100	.0014	1.89	-	1,570
Nov., 1889-April, 1890, .	55,000	42	.0929	.0341	4.28	1.3000	.0017	1.43	-	4,236
May-Oct., 1890, . .	89,000	64	.0121	.0309	6.83	1.5900	.0013	1.65	.24	14,200
Nov., 1890-April, 1891, .	114,000	40	.4933	.0601	5.34	.9100	.0100	1.46	.45	24,970
May-Oct., 1891, . .	118,000	65	.0789	.0386	9.23	1.5100	.0273	1.67	.34	13,300
Nov., 1891-April, 1892, .	124,000	41	.3765	.0821	7.64	1.1800	.0319	1.66	.55	42,100
May-Oct., 1892, . .	128,000	66	.2562	.0653	9.40	1.7500	.0209	2.09	.49	64,640
Nov., 1892-April, 1893, .	118,000	39	.9201	.1396	6.47	1.0000	.0190	2.00	.94	142,300
May-Oct., 1893, . .	95,000	66	.0384	.0486	7.86	3.1600	.0096	3.27	.34	38,600
Nov., 1893-April, 1894, .	93,000	42	.9310	.1087	6.58	2.2300	.1270	3.30	.75	125,000
May-Oct., 1894, . .	72,000	67	.0858	.0370	11.18	3.7900	.0042	3.93	.28	33,700

Table showing Average Results of Analyses of Effluent of Filter No. 2, by Six Month Periods.

[Parts per 100,000.]

Period.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan.-April, 1888,	41,000	36	.2757	.0173	2.50	.0100	.0003	.26	–	3,750
May-Oct., 1888,	24,000	62	.1811	.0120	6.60	1.0400	.0166	1.23	–	184
Nov., 1888-April, 1889,	23,000	43	.0039	.0071	4.41	.9200	.0014	.94	–	14
May-Oct., 1889,	33,000	63	.0021	.0090	5.47	1.2700	.0003	1.30	–	28
Nov., 1889-April, 1890,	44,000	42	.0175	.0119	4.38	1.1800	.0040	1.22	–	169
May-Oct., 1890,	65,000	64	.0015	.0105	5.89	1.9300	.0000	1.95	.08	39
Nov., 1890-April, 1891,	64,000	41	.2438	.0188	4.62	.9300	.0029	1.16	.13	218
May-Oct., 1891,	60,000	64	.3866	.0331	10.05	1.0300	.0138	1.42	.31	16
Nov., 1891-April, 1892,	26,000	42	.3432	.0264	5.93	.6800	.0012	1.01	.24	14
May-Oct., 1892,	29,000	63	.8121	.0306	10.10	2.1300	.0127	1.83	.22	47
Nov., 1892-April, 1893,	24,000	40	.1824	.0197	6.09	1.1200	.0078	1.31	.18	3,700
May-Oct., 1893,	45,000	62	.2039	.0098	7.72	3.5700	.0166	3.63	.12	104
Nov., 1893-April, 1894,	55,000	42	.3285	.0258	6.26	2.4100	.1120	2.83	.25	1,085
May-Oct., 1894,	39,500	64	.0011	.0131	8.89	3.2100	.0001	3.23	.10	569

Table showing Average Results of Analyses of Effluent of Filter No. 4, by Six Month Periods.

[Parts per 100,000.]

Period.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan.-April, 1888,	46,000	37	.1759	.0205	2.70	.0200	.0005	.20	–	2,362
May-Oct., 1888,	23,000	62	.4380	.0477	5.91	.3500	.0035	.79	–	27
Nov., 1888-April, 1889,	15,000	43	.0815	.0149	3.93	.3000	.0007	.39	–	10
May-Oct., 1889,	20,000	64	.0041	.0146	4.67	.6300	.0002	.67	–	60
Nov., 1889-April, 1890,	30,000	43	.0016	.0107	4.62	1.2500	.0001	1.27	–	27
May-Oct., 1890,	33,000	62	.0016	.0136	6.62	1.3300	.0000	1.35	.14	295
Nov., 1890-April, 1891,	34,000	41	.1019	.0186	5.02	.9100	.0011	1.03	.18	312
May-Oct., 1891,	40,000	62	.0128	.0119	6.48	1.8800	.0004	1.91	.15	57
Nov., 1891-April, 1892,	51,000	42	.1306	.0299	6.17	.7700	.0006	.93	.31	70
May-Oct, 1892,	35,000	64	.9123	.0784	7.46	.5300	.0044	1.41	1.25	107
Nov., 1892-April, 1893,	38,000	42	.0571	.0245	5.65	1.0000	.0008	1.09	.31	48
May-Oct., 1893,	30,000	63	.1250	.0366	7.68	1.7200	.0065	1.89	.39	32
Nov., 1893-April, 1894,	23,000	43	.1895	.0315	5.86	1.1400	.0014	1.35	.37	89
May-Oct., 1894,	19,700	64	.7678	.0368	9.25	1.7400	.0108	2.44	.49	149

Table showing Average Results of Analyses of Effluent of Filter No. 5 A, by Six Month Periods.

[Parts per 100,000.]

Period.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Sept. 15-Oct., 1891, .	29,000	63	.1998	.0330	6.69	.6300	.0178	.87	.26	183,800
Nov., 1891-April, 1892, .	90,000	42	.7524	.0866	7.52	1.2200	.0238	2.00	.51	204,700
May-Oct., 1892, . .	80,000	66	.7010	.0687	9.75	.8900	.0206	1.60	.67	66,800
Nov., 1892-April, 1893, .	108,000	41	.9327	.1695	6.89	1.2800	.0206	2.26	1.03	307,200
May-Oct., 1893, . .	114,000	66	.1502	.0707	8.53	2.1900	.0077	2.44	.39	114,900
Nov., 1893-April, 1894, .	101,000	41	.7677	.1421	6.39	2.2300	.0555	3.15	.84	193,700
May-Oct., 1894, . .	78,300	67	.3388	.0620	11.09	3.2900	.0170	3.69	.39	71,000

Table showing Average Results of Analyses of Effluent of Filter No. 6, by Six Month Periods.

[Parts per 100,000.]

Period.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Jan.-April, 1888, . .	36,000	37	.2396	.0202	2.50	.0200	.0005	.25	–	35,300
May-Oct., 1888, . .	45,000	63	.0211	.0100	6.07	1.1100	.0037	1.15	–	154
Nov., 1888-April, 1889, .	30,000	42	.0160	.0075	4.41	.9700	.0002	.99	–	389
May-Oct., 1889, . .	45,000	64	.0037	.0100	4.88	1.6800	.0002	1.70	–	494
Nov., 1889-April, 1890, .	49,000	42	.0097	.0166	4.71	1.2300	.0005	1.27	–	1,361
May-Oct., 1890, . .	56,000	63	.0026	.0166	6.24	1.5800	.0001	1.61	.10	11,800
Nov., 1890-April, 1891, .	62,000	41	.3060	.0327	4.27	1.1100	.0034	1.42	.22	12,600
May-Oct., 1891, . .	70,000	64	.0036	.0202	9.09	1.7600	.0006	1.80	.20	1,615
Nov., 1891-April, 1892, .	34,000	42	1.0189	.0591	7.54	.1900	.0008	1.12	.57	3,600
May-Oct., 1892, . .	54,000	66	.3419	.0273	9.40	2.7800	.0246	3.13	.23	5,100
Nov., 1892-April, 1893, .	62,000	41	.9265	.0852	6.73	1.2200	.0798	2.20	.57	21,100
May-Oct., 1893, . .	78,000	65	.0330	.0334	8.55	2.9800	.0258	3.09	.21	6,100
Nov., 1893-April, 1894, .	66,000	41	.1812	.0546	6.15	2.2300	.2662	2.73	.56	7,980
May-Oct., 1894, . .	51,900	65	.0843	.0403	12.37	3.6200	.0255	3.78	.31	13,000

Table showing Average Results of Analyses of Effluent of Filter No. 7, by Six Month Periods.

[Parts per 100,000.]

PERIOD.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	AMMONIA.		Chlorine.	NITROGEN AS		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Jan.-April, 1888, . .	40,000	37	.1506	.0135	2.35	.0100	.0004	.16	-	8,900
May-Oct., 1888, . .	19,000	62	.1446	.0166	6.22	.5200	.0097	.68	-	93
Nov., 1888-April, 1889, .	10,000	45	.0013	.0060	3.91	.7600	.0000	.77	-	6
May-Oct., 1889, . .	15,000	64	.0012	.0078	4.71	1.6000	.0001	1.61	-	202
Nov., 1889-April, 1890, .	30,000	43	.0027	.0110	4.38	1.0500	.0001	1.07	-	690
May-Oct., 1890, . .	32,000	63	.0177	.0113	6.47	2.2200	.0006	2.25	.09	305
Nov., 1890-April, 1891, .	35,000	41	.5263	.0208	4.50	.5100	.0046	.98	.18	930
May-Oct., 1891, . .	20,000	64	.4543	.0187	7.90	2.1900	.0058	2.60	.13	257
Nov., 1891-April, 1892, .	21,000	43	.0179	.0089	6.62	1.3700	.0009	1.40	.09	14
May-Oct., 1892, . .	18,000	62	.0414	.0117	9.09	2.4800	.0075	2.54	.11	2,257
Nov., 1892-April, 1893, .	35,000	41	1.5153	.0671	6.79	.4400	.0115	1.80	.68	4,500
May-Oct., 1893, . .	38,000	67	.3443	.0485	7.74	3.0900	.0515	3.50	.37	850
Nov., 1893-April, 1894, .	14,000	43	.0069	.0107	5.24	2.2400	.0012	2.26	.11	78
May-July, 1894, . .	21,000	62	.0663	.0115	9.50	2.5600	.0003	2.63	.11	72

Table showing Average Results of Analyses of Effluent of Filter No. 9 A, by Six Month Periods.

[Parts per 100,000.]

PERIOD.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	AMMONIA.		Chlorine.	NITROGEN AS		Total Nitrogen.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Nov., 1890-April, 1891, .	102,000	40	1.0566	.0303	3.88	.2800	.0033	1.21	.17	1,900
May-Oct., 1891, . .	115,000	66	.0603	.0163	10.84	2.1800	.0135	2.27	.17	430
Nov., 1891-April, 1892, .	23,000	42	1.0431	.0528	7.74	.4300	.0084	1.38	.48	740
May-Oct., 1892, . .	86,000	66	.1657	.0197	9.28	2.0300	.0172	2.21	.19	980
Nov., 1892-April, 1893, .	112,000	40	.7742	.0684	6.92	1.1900	.0047	1.94	.51	24,600
May-Oct., 1893, . .	110,400	65	.0410	.0261	8.05	2.8800	.0017	2.96	.19	1,660
Nov., 1893-April, 1894, .	86,000	40	1.4418	.0834	6.55	1.8500	.0142	3.18	.56	20,500
May-Oct., 1894, . .	72,000	65	.0096	.0179	9.56	3.5400	.0007	3.58	.14	492

Table showing Results of Analyses of "Regular" Sewage by Six Month Periods.

[Parts per 100,000.]

Period.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble	Total Nitrogen.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan.-April, 1888,	.94	.57	.13	1.71	2.61	-	1,155,000
May Oct., 1888,	1.97	.86	.17	3.03	6.33	-	1,158,000
Nov., 1888-April, 1889,	1.52	.37	.19	1.85	5.30	-	595,000
May Oct., 1889,	2.12	.68	.34	2.85	5.04	-	857,000
Nov., 1889-April, 1890,	1.51	.63	.34	2.27	4.88	-	488,000
May-Oct., 1890,	2.05	.65	.39	2.74	6.06	3.08	1,415,000
Nov., 1890-April, 1891,	1.53	.62	.31	2.27	4.73	2.98	621,000
May-Oct., 1891,	2.62	.76	.38	3.40	9.00	3.70	889,000
Nov., 1891-April, 1892,	2.40	.91	.38	3.47	7.00	4.88	815,000
May Oct., 1892,	2.54	.70	.32	3.23	9.81	3.88	733,000
Nov., 1892-April, 1893,	2.40	.73	.36	3.16	7.24	4.48	970,000
May-Oct., 1893,	2.74	.53	.26	3.12	9.66	2.68	851,000
Nov., 1893-April, 1894,	2.83	.65	.28	3.39	6.92	3.68	820,000
May-Oct., 1894,	3.75	.58	.24	4.02	9.36	3.04	1,472,000

An exhaustive study of the results presented in the foregoing table means, of course, frequent reference to the individual results and to the corresponding accounts of the work of the filters. They are of importance in connection with the study of the quantitative and qualitative efficiency, as well as of the permanency, of sewage filters. But at this time it is the purpose to discuss the changes in conditions which have taken place during the investigations, and especially to note the differences in conditions and in results during the winter of 1888–89 in comparison with those of more recent winters.

I. Composition of Sewage.

The results of analyses of sewage in the table on the last page show that the free ammonia has increased more than twofold during these investigations. With regard to the albuminoid ammonia the change has been comparatively slight, but it is seen from the analyses that the amount of crude organic matter in the sewage

during the winter of 1888–89 was only about one-half of the average amount present during the past three winters. The fairest idea of the relative strength of the sewage may be obtained from the amounts of total nitrogen, which is calculated as fourteen-seventeenths of the sum of the free ammonia and double the albuminoid ammonia. In this connection it is instructive to consult the discussion on the decomposition of fresh sewage on page 460.

II. *Rate of Filtration.*

The tables of results from the older filters show that on the whole larger quantities of sewage have been applied during the recent than during the earlier years of the investigations. This is especially noticeable upon examination of the rates of filtration during the winter of 1888–89, when in the case of some filters the quantities of applied sewage were less than half of those of more recent winters.

III. *Quantitative Efficiency expressed in Units of Unoxidized Organic Matter.*

The quantitative efficiency of a filtering material for the purification of sewage, when accurately considered, should be stated in units of unoxidized and unpurified organic matter. The reason of this is the marked variation in the strength of sewage, as was pointed out in the chapter on composition of sewage. Knowing that the rate of filtration alone is inadequate for precise estimation, it appears from our present knowledge that the quantitative efficiency can be best stated in units obtained by combining with the rate of filtration the strength of the sewage.

Multiplying the rate (in thousand gallons per acre daily for six days in a week) by the total nitrogen (in parts per 100,000) of the applied sewage, we have for the several filters the results presented in the table below. These results show very clearly that the amount of work for the filters to do in the earlier winters, and especially that of 1888–89, was much less than that in later ones.

Table showing Amount of Sewage applied to the Several Filters, by Six Month Periods, and expressed in Units of Unoxidized Organic Matter.

Period.	Filter Nos.						
	1.	2.	4.	5 A.	6.	7.	9 A.
Jan.–April, 1888,	62	70	79	-	62	68	-
May-Oct , 1888,	182	73	79	-	136	58	-
Nov , 1888-April, 1889,	128	43	28	-	55	18	-
May-Oct., 1889,	185	94	57	-	128	43	-
Nov., 1889-April, 1890,	125	100	68	-	111	68	-
May-Oct., 1890,	225	178	90	-	153	88	-
Nov., 1890-April, 1891,	259	145	77	-	141	79	231
May-Oct , 1891,	401	204	136	99	238	68	39
Nov , 1891-April, 1892,	430	100	177	312	118	73	81
May-Oct., 1892,	413	94	113	258	174	58	278
Nov., 1892-April, 1893,	373	76	120	341	196	111	354
May-Oct., 1893,	296	140	94	356	243	119	344
Nov., 1893-April, 1894,	315	186	78	342	224	47	291
May-Oct., 1894,	289	157	79	315	209	84	289

IV. Qualitative Efficiency expressed as the Percentage of Unoxidized Nitrogen removed.

A full account of the work done by a sewage filter demands a comprehensive statement of the quality of the effluent as compared with that of the unpurified sewage. It is a matter of a difficult and arbitrary nature, in the light of our present knowledge, to find a means of expressing the qualitative efficiency of a filter in which an approximately correct value is given to the nitrogen in the form of free ammonia. The reason of this is the fact that free ammonia (present in comparatively large amounts in sewage) represents unoxidized nitrogen, but not nitrogenous organic matter, and also appears to be coincident with oxidation of carbonaceous matter requiring time and bacterial action. The fairest way of expressing the degree of purification, so far as concerns the amount of work done, seems to be the percentage which is removed of the total unoxidized (and unpurified) nitrogen.

The method which is outlined above is carried out for the several

filters in the first table below. For the sake of greater clearness several explanatory statements will be repeated with regard to the method of calculation. In the station sewage the unoxidized nitrogen corresponds to the total nitrogen as, generally speaking, nitrogen in the form of nitrites and nitrates is absent. The total nitrogen is present in the free and albuminoid ammonias from which it is calculated as fourteen-seventeenths of the sum of the free ammonia and double the albuminoid ammonia.

In the effluent the unoxidized nitrogen is also present in the form of free and albuminoid ammonias, and is calculated in the same way as in the case of sewage. The nitrogen corresponding to the difference between the unoxidized nitrogen of the sewage and that of the effluent exists in several forms. By far the largest part of it is to be found in the effluent in the form of nitrates; the effluents frequently contain nitrogen in the form of nitrites, but it is rare that the amount is more than a trifling one. A certain amount of the nitrogen of the unpurified sewage is stored in the filtering material. In several instances the stored nitrogen in the upper layers of filters has been removed by scraping, as was described in previous reports. The remainder of the nitrogen, unaccounted for in the effluents, passes off into the atmosphere, probably as nitrogen gas. From this explanation it is plain that the percentages of unoxidized nitrogen in the first table below are calculated from, and correspond to, the differences in the unoxidized nitrogen of the sewage and that of the effluents.

For the sake of comparison and as a matter of reference there are presented in the second table beyond the percentages of the crude organic matter, as indicated by the albuminoid ammonia, which have been removed by the several filters. These results, like those in the first table, are obtained from the difference in the amounts present in the sewage and the effluents.

The results in the two following tables show clearly that during the past two or three winters, when the sewage has been stronger and the rate of filtration higher, the percentage of removal of unoxidized nitrogen and of organic matter has been less than during earlier winters and especially that of 1888–89.

Table showing Per Cent. of Unoxidized Nitrogen removed from Sewage by each of the Several Filters, by Six Month Periods.

PERIOD.	FILTER NOS.						
	1.	2.	4.	5 A.	6.	7.	9 A.
Jan.-April, 1888, ...	76	85	90	-	87	92	-
May-Oct., 1888, ...	98	94	96	-	99	95	-
Nov., 1888-April, 1889, ...	94	99	95	-	99	99	-
May-Oct., 1889, ...	97	99	99	-	99	99	-
Nov., 1889-April, 1890, ...	94	99	99	-	98	99	-
May-Oct., 1890, ...	98	99	99	-	99	99	-
Nov., 1890-April, 1891, ...	76	90	95	-	87	79	60
May-Oct., 1891, ...	96	89	99	94	99	88	98
Nov., 1891-April, 1892, ...	87	91	96	78	76	99	73
May-Oct., 1892, ...	92	78	73	79	92	98	96
Nov., 1892-April, 1893, ...	65	94	97	67	70	57	81
May-Oct., 1893, ...	97	94	95	93	98	88	98
Nov., 1893-April, 1894, ...	77	91	94	75	94	99	68
May-Oct., 1894, ...	97	99	83	91	97	98	99

Table showing Per Cent. of Organic Matter, represented by Albuminoid Ammonia, removed from Sewage by each of the Several Filters, by Six Month Periods.

PERIOD.	FILTER NOS.						
	1.	2.	4.	5 A.	6.	7.	9 A.
Jan.-April, 1888, ...	93	97	96	-	96	98	-
May-Oct., 1888, ...	98	99	94	-	99	98	-
Nov., 1888-April, 1889, ...	93	98	96	-	98	98	-
May-Oct., 1889, ...	96	99	98	-	99	99	-
Nov., 1889-April, 1890, ...	95	98	98	-	97	98	-
May-Oct , 1890, ...	95	98	98	-	97	98	-
Nov , 1890-April, 1891, ...	90	97	97	-	95	96	95
May-Oct., 1891, ...	95	96	98	-	97	97	98
Nov., 1891-April, 1892, ...	91	97	97	90	85	99	94
May-Oct., 1892, ...	91	96	89	90	97	98	97
Nov., 1892-April, 1893, ...	79	97	97	77	89	91	89
May-Oct., 1893, ...	93	98	93	87	95	91	96
Nov., 1893-April, 1894, ...	86	96	95	78	93	98	89
May-Oct., 1894, ...	93	98	94	89	95	98	97

V. *Combination of Quantitative and Qualitative Efficiencies of Filters as shown in Sections III. and IV.*

In order to make a complete comparison of work done by filters it is necessary to take into consideration both their quantitative and qualitative efficiencies. To find a standard by which this may be satisfactorily done is a very difficult matter, owing to several complications and to the use of factors of an arbitrary nature. No method which is thoroughly satisfactory has occurred to us, and the best which we can offer at this time is a combination of the results given in the last two sections. It is quite proper that the results be treated in this way provided that it is clearly understood how the results were obtained, and the limitations in the conclusions which may be correctly drawn from them. In fact, when the five sections are considered together this (fifth) one is a logical step and strengthens the line of reasoning employed in this chapter.

The next table shows the amount (in units) of unoxidized nitrogen which has been removed by the several filters from sewage. The results were calculated from the differences in the ammonias in the sewage and in the effluents. Thus, in the case of Filter No. 1, January to April, 1888, the 47 units in the next table mean that this amount [76 per cent. (page 523) of 62 units (page 521)] of the total unoxidized nitrogen of the applied sewage was removed by filtration; or, to be more exact, the difference, 15 units, appeared in the effluent as free or albuminoid ammonia, and the 47 units represent the result of nitrification, storage and of atmospheric loss.

In addition to the necessarily arbitrary way of handling the nitrogen in the free and albuminoid ammonias it is to be pointed out that these results do not show differences in amounts of stored organic matter, or in amounts of organic matter removed by scraping, or in amounts of atmospheric loss; neither do they show in absolute terms the amounts of organic matter remaining in the several effluents. Furthermore, if these results are directly comparable it assumes that the amount of organic matter in the effluent varies directly with the rate of filtration. It is possible that this last assumption is mathematically correct, but owing to complications from several factors we have no conclusive proof that such is the case.

No detailed discussion is offered of this table which, in spite of its shortcomings, is interesting and instructive with regard to a comparison of the results of recent winters with those of earlier ones.

Table showing Amount (in Units) of Unoxidized Nitrogen removed from Sewage by the Several Filters, by Six Month Periods.

Period.	Filter Nos.						
	1.	2.	4.	5 A.	6.	7.	9 A.
Jan.-April, 1888,	47	60	71	-	54	63	-
May-Oct , 1888,	178	68	58	-	135	55	-
Nov., 1888-April, 1889,	120	42	26	-	55	18	-
May-Oct., 1889,	180	93	56	-	127	42	-
Nov., 1889-April, 1890,	117	99	67	-	109	67	-
May-Oct , 1890,	220	176	89	-	152	87	-
Nov., 1890-April, 1891,	197	131	73	-	122	63	139
May-Oct., 1891,	385	182	135	93	236	60	38
Nov., 1891-April, 1892,	376	91	170	243	90	72	59
May-Oct , 1892,	380	73	83	204	160	57	267
Nov., 1892-April, 1893,	242	71	116	229	137	63	287
May-Oct., 1893,	289	132	89	331	236	99	337
Nov , 1893-April, 1894,	243	170	73	257	210	47	198
May-Oct., 1894,	281	155	66	286	202	83	286

VI. Temperature.

At the very outset of these investigations the marked effect of temperature upon the purification of sewage was noted, and each year this point has been a subject of special study. In each of the reports will be found the results of experiments throwing light upon this matter. During the past year the influence of temperature upon nitrification under some new conditions has received considerable attention, as has been described in the chapter beginning on page 474. In this connection it is also instructive to remember that during the winter months the results obtained from the in-door filters (Nos. 11–32) have been more satisfactory than those from the larger filters, which have been more exposed to the cold.

It has been the custom to warm the sewage during the winter months so that when applied it shall be at about 45° F., which is, approximately, the temperature in the sewer. As has been stated several times, the pipe through which the sewage passes from the sewer to the station lies on the bed of the river for a distance of about 3,000 feet. To overcome the chilling thus received is the reason why the sewage is warmed at the station before being applied to the filters.

With the appliances at hand the temperature of the sewage has been controlled with fair success during the several winters, and, speaking in general terms, this point does not seem to be a factor in explaining the different results obtained during the several winters. It may be mentioned, however, that a study of the individual results will show that on several occasions for a day or so at a time there has been a marked variation in the temperature of the applied sewage.

It is the temperature of the air in which there has been the most variation, as is shown by the results of observations made both at the station and by the Essex Company. In the next table is given a summary of the temperatures of the air for the past ten years. These results show that the temperature of the air during the past two winters has been less than during former ones and especially that of 1888–89.

A fair idea of the temperatures of the effluents during the several winters may be obtained from the tables on pages 515–518. By averaging these results it will be found that the temperature of the effluents during the winter of 1888–89 was about 2° F. higher than that of the winters of 1889–90, 1891–92 and 1893–94; and about 3° F. higher than that of the winters of 1890–91 and 1892–93.

Table showing the Temperature of the Air at Lawrence * *by Months, 1885-1894, obtained by averaging the Mean Maximum and Mean Minimum Temperatures for each Day.*

[Degrees F.]

	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
January,	23.85	23.09	20.30	15.46	31.38	28.68	26.74	25.02	16.85	25.82
February,	18.82	23.08	25.02	23.63	22.29	30.14	28.57	26.06	23.73	22.17
March,	26.55	31.73	29.83	29.76	36.02	32.24	31.36	31.33	31.89	40.34
April,	47.39	49.54	42.58	40.94	48.74	45.50	48.44	47.97	43.52	46.74
May,	56.87	57.45	60.60	54.68	61.87	58.39	57.08	57.39	56.80	58.61
June,	69.37	65.07	65.35	67.45	69.12	64.92	66.45	71.15	66.45	68.93
July,	75.26	71.72	74.52	69.60	71.22	72.15	70.87	75.06	71.24	73.87
August,	69.02	68.91	65.44	69.49	67.93	69.76	71.54	69.70	69.34	69.00
September,	60.15	61.75	55.79	58.32	62.73	61.77	68.35	61.52	58.55	64.95
October,	50.49	49.32	47.58	44.39	46.40	48.62	49.61	50.23	53.52	51.87
November,	41.50	39.27	37.74	39.85	41.09	37.47	39.33	37.67	38.56	34.90
December,	29.10	24.42	28.21	29.88	33.45	21.08	36.88	26.11	25.61	27.00

* These observations were made by the Essex Company.

VII. *Protection of the Surface of Sewage Filters.*

The experience of the first winter showed plainly that considerable difficulty attended the application, during severe winter weather, ot sewage to filters with smooth surfaces and with no protection from the weather. During the second winter (1888–89) the surfaces were covered with canvas or with boards. This was also the case during the next winter, but since that time some of the filters have been left uncovered, as will be seen from the following summary of the detailed notes presented on pages 497–505. Filter No. 7 does not appear here, because for the greater part of the time the sewage was applied to the sub-surface; Filters No. 5 A and 9 A were not constructed until about the middle of the period covered by these investigations.

Winter.	Number of Filter.					
	1.	2.	4.	5 A.	6.	9 A.
1887-88, . . .	Uncovered.	Uncovered.	Uncovered.	–	Uncovered.	–
1888-89, . . .	Canvas.	Canvas.	Boards over trenches.	–	Canvas.	–
1889-90, . . .	Canvas.	Canvas.	Canvas.	–	Canvas.	–
1890-91, . . .	Uncovered.	Uncovered.	Uncovered.	–	Uncovered.	Uncovered.
1891-92, . . .	Uncovered.	Canvas.	Boards over trenches.	Uncovered.	Canvas.	Uncovered.
1892-93, . . .	Uncovered.	Canvas.	Canvas.	Uncovered.	Uncovered.	Canvas.
1893-94, . . .	Uncovered.	Boards over trenches.	Boards over trenches.	Uncovered.	Canvas.	Uncovered.

The covers were not in all cases put on at the beginning of cold weather, and in making a detailed study of the results it will be necessary to consult the original references or the summary of them already referred to. Experience has clearly shown that this protection of the surfaces has a beneficial effect, because it prevents, to a considerable extent, the formation of frost in the sand, and thereby aids materially in the prevention of a diminution in the activity of the nitrifying organisms. The prevention of frost, in the case of filters of coarse material, is of marked advantage, for the reason that the tendency toward unequal passage of sewage through the filter is much less, as is pointed out in the next section.

It is to be noted here that snow has been removed in all cases from the surface of the filters.

VIII. *Disturbance of Surface Layers of Filters with regard to Uniformity of Passage of Sewage through the Filtering Area.*

Under this topic there are two points to which it is desired to call attention: first, the disturbances of the surface layers during the cold season, when it has been the custom to make and record observations on the depths of frost, etc.; and, second, those disturbances which have been made, usually during warmer weather, whereby surface clogging and stratification have been removed.

Up to Jan. 1, 1894, it was customary, during the winter months, to pick holes in the surface of the sewage filters in order to measure the depth of frost and to aid the passage of sewage through the filters. Since that time this custom has been abandoned, and it is believed that it is a distinct gain so far as the filters of coarse material are concerned, because in its absence the passage of the sewage is more uniform. Its influence upon the filters of fine material is inappreciable, owing to the relatively large amount of sewage held by capillarity in the pores of the material. In the winters of 1888–89 and 1889–90 this was not such a prominent factor as it has been in later winters, owing to the fact that at that time more of the filters were covered and the amount of work for them to do was much less.

Concerning the second point under this topic, that of disturbances of surface to break up clogging and stratification, it will be recalled that during the first two years of these investigations the amount of organic and other matters stored in the upper layers of the filters was so slight that excellent results, under the existing conditions, were obtained in the absence of any systematic or marked disturbances of the surface. Beginning in 1890 it was found to be necessary to rake the surfaces of the filters at frequent intervals; and later the upper portions were disturbed for the sake of removing stratified layers. Occasionally, with the view to lessen the amount of stored organic matter, the filters have been spaded over corresponding to ploughing. One of the chief objects of these lines of treatment was to allow the entrance of more air into the pores of the filters, and in this respect these disturbances of the upper layers have been very successful. Another result of this treatment has been to make the coarser filters much more porous for a time, and to allow the sewage to pass through the filter in limited areas. In the case of some filters this has been very noticeable at times during

the latter part of the investigations, and in some instances the passage of the sewage through the filter has been too rapid to be consistent with satisfactory purification. This is well illustrated in the case of Filter No. 5 A, as will be found beyond in the detailed account of the work of the filters.

The effect upon the quality of the effluent of differences in the rate at which it flows from the filter has recently been quite marked in the case of filters of coarse material during the winter months. This is brought out clearly by the results in the next table, which also shows that the quality of the effluent of fine filters is independent of the rate at which the effluent flows from the filter. The word maximum is used for convenience in distinction from minimum, but it really means a comparatively high rate at which it has been learned that there may be collected a sample which will be representative of the entire flow, so far as quality is concerned.

Comparison of these results with corresponding ones for former years, as presented in the special report for 1890 and the annual report for 1891, indicates that in the case of the filters of coarse material the increased porosity has caused a diminution in the quality of the effluent.

Table showing Results of Analyses of Samples of Effluent representing Different Portions of the Daily Flow of the Several Filters.

Filter No. 1.

[Parts per 100,000.]

Date — 1894.	Period of Flow.	Temperature. — Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	Maximum.	38	Decided.	.65	1.6440	.1748	6.04	1.5300	.3960	.84	305,340
" .	Minimum	37	Decided.	.31	.8000	.0772	6.26	2.4600	.1780	.34	2,800
February, .	Maximum.	36	Slight.	.70	1.7450	.1435	5.62	1.3900	.0850	.95	113,500
" .	Minimum.	36	Slight.	.29	.8467	.0640	5.56	2.6200	.1067	.56	15,933

Filter No. 2.

January, .	Maximum.	37	None.	.08	.6260	.0332	6.35	2.1700	.1060	.28	2,527
" .	Minimum.	37	None.	.08	.6260	.0332	6.35	2.1700	.1060	.28	1,780
February, .	Maximum.	36	None.	.06	.1416	.0230	5.76	2.3900	.0190	.21	371
" .	Minimum.	36	None.	.06	.1416	.0230	5.76	2.3900	.0190	.21	268

Filter No. 4.

January, .	Maximum.	40	None.	.14	.0146	.0246	6.11	.5700	.0004	.30	85
" .	Minimum.	40	None.	.14	.0146	.0246	6.11	.5700	.0004	.30	92
February, .	Maximum.	39	None.	.21	.1315	.0370	5.43	.4600	.0006	.47	108
" .	Minimum.	39	None.	.21	.1315	.0370	5.43	.4600	.0006	.47	112

Table showing Results of Analyses of Samples of Effluent representing Different Portions of the Daily Flow of the Several Filters — Concluded.

Filter No. 5 A.

[Parts per 100,000.]

Date — 1894.	Period of Flow.	Temperature. Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	Maximum.	37	Decided.	.72	1.4440	.2332	5.71	1.2600	.2520	1.16	420,400
" .	Minimum.	37	V. slight.	.25	.7440	.0752	5.69	2.7100	.0078	.33	45,420
February, .	Maximum.	37	Decided.	.43	.7325	.1052	5.87	1.9700	.0069	.71	104,625
" .	Minimum.	37	V. slight.	.12	.3900	.0493	5.71	3.4700	.0043	.27	1,530

Filter No. 6.

Date — 1894.	Period of Flow.	Temperature. Deg. F.	Turbidity.	Color.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	Maximum.	38	V. slight.	.22	.1588	.0540	6.32	2.0900	.5000	.67	3,330
" .	Minimum.	38	V. slight.	.18	.1944	.0456	6.09	1.6300	.6300	.65	1,510
February, .	Maximum.	38	V. slight.	.20	.0935	.0510	6.03	1.8200	.2175	.48	5,050
" .	Minimum.	38	V. slight.	.16	.1207	.0413	6.44	1.7800	.2700	.37	264

Filter No. 9 A.

Date — 1894.	Period of Flow.	Temperature. Deg. F.	Turbidity.	Color.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	Maximum.	37	Slight.	.36	1.5680	.0792	6.72	1.7100	.0180	.49	25,000
" .	Minimum.	36	Slight.	.30	1.5267	.0640	6.42	2.0200	.0163	.36	10,620
February, .	Maximum.	36	Decided.	.56	1.8580	.1080	5.64	1.1900	.0290	.79	45,800
" .	Minimum.	35	V. slight.	.31	1.1667	.0533	5.27	1.5900	.0022	.36	20,330

Conclusions as to the Relative Efficiency of the Filters during the Winter of 1888–89 and that of Later Ones.

Taking the several factors given above and applying them to each filter we may conclude that the deterioration during the later winters in the quality of effluent has been due to the following causes : —

1. To the higher rate of filtration.

2. To the increased strength of the applied sewage.

3. To the lessened protection from winter weather, causing a diminution in the activity of the nitrifying organisms.

4. To the less uniform passage of the sewage through the material in the case of the coarser filters.

General Summary.

The purification of sewage during winter weather has received considerable attention in the reports for the past three years. New light has been obtained during the past year, and we may sum up our present knowledge as follows : —

1. In Massachusetts the qualitative efficiency of sewage filters may be less in winter, owing chiefly to inactivity of micro-organisms caused by exposure to low temperature; and from our present knowledge it does not appear advisable to allow filters exposed to the weather to rest in winter, even for limited periods. In this connection it should be remembered that resting during the month of November (mean temperature 34.9° F.) was found to be too long in the case of Filters Nos. 1, 6 and 9 A.

2. Qualitative deterioration is a serious matter in winter, because when a period of biological reconstruction is necessary, nitrification cannot become promptly re-established, as is the case in summer, but requires a period of several weeks and possibly months.

3. While nitrification cannot be readily re-established in winter, it has been learned that in those cases where this process was in a satisfactory state at the beginning of the winter it could, by proper treatment, be preserved during the cold season.

4. Frost, in the interstices of sewage filters, reduces their quantitative as well as the qualitative efficiency.

5. The warmer the sewage (within limits) the better are the results, both qualitatively and quantitatively, owing to the less likelihood of frost and its more ready removal if it does occur. In the account of Filter No. 11 it will be found that sewage may be safely applied to filters if heated to a temperature of 100° F., but that the biological processes are interfered with when the applied sewage has a temperature of 150° F.

6. The less exposure to cold winter weather which the surface of the filter undergoes the greater the number of heat units saved and the better will be the results, both quantitatively and qualitatively.

7. The application of sewage to limited portions, such as trenches, in the case of filters of fine material, concentrates the heat, thereby aiding in preserving the biological processes and in maintaining the qualitative efficiency.

8. In the case of experimental filters of coarse material thoroughly underdrained, poor results during the winter follow the application of sewage to limited portions, owing to the rapid and irregular passage through the filter.

9. The composition of sewage, and particularly the amount of sludge applied to filters, is a much more marked factor in winter than in summer, even in the case of experimental filters where especial lines of treatment to keep the filters in operation are feasible.

Comparison of Conditions of Experimental Filtration with those in Actual Practice.

During the past two years frequent visits have been made by the writer to the sewage purification plants at Framingham, Marlborough and Gardner; and the most important of the remaining sewage disposal works in Massachusetts have been occasionally inspected. An account of the work of sewage filters in actual operation in Massachusetts will be found beyond. In this connection a comparison is given of the conditions in actual practice with those of the experimental Lawrence filters, as follows: —

I. Strength of Sewage.

The strength of the Lawrence sewage as pumped at the station is such that the Lawrence results may be fairly considered to be representative, so far as the sewages from Massachusetts cities and towns are concerned, as was pointed out in the 1893 Report, page 409. In fact it is stronger than any which has been regularly examined.

II. State of Decomposition of Sewage.

With regard to the composition of the Lawrence sewage it may also be noted that it is somewhat more decomposed than in the case of several of the sewages found at different places throughout the State. This is caused by bacterial action during the interval of time which elapses during the passage of the sewage to the station, — a condition which would exist in sewage disposal works on a large scale, where the filter field is several miles distant from the lateral sewers, or where the sewage passes through a settling tank.

III. Temperature.

The temperature of the sewage at Lawrence during the winter months may be considered normally to be about 45° F. At Framingham the temperature of the sewage in winter is 48° to 50° F., while at Marlborough and at Gardner the temperature ranges ordinarily from 38° to 42° F. From our present knowledge it appears that the temperature of the Lawrence sewage is approximately normal during the winter except in those cases where there is an unusually large amount of surface water or ground water entering the sewers. The temperature of the air and of the soil, etc., does not differ essentially in experimental conditions from those in actual practice.

IV. Size of Filters and of Materials.

With experimental filters of the size of those at Lawrence it is fair to say that the results obtained from them serve us as a reliable guide, so far as the size of the filtering materials studied is concerned.

V. Distribution of Sewage.

The distribution of the sewage upon the filters, in many cases in actual practice, is not taken into consideration with sufficient care and is often less effectively accomplished than is the case at Lawrence. The excellent distribution of sewage at Framingham, however, shows clearly that this may be carried out on a large scale as well as is done at the Experiment Station.

VI. Lateral Filtration and Arrangement of Under-drains.

In the case of the experimental filters at Lawrence, each one of them, except Filter No. 10, is completely underdrained by layers of stone and gravel. In those cases of fine material in which there are saturated layers above the under-drains, the conditions correspond very fairly to those in actual practice in which the material would be less completely drained.

It is with filters of coarse material in which the experimental conditions would differ considerably from those in actual practice. In the experimental filters with under-drains beneath the entire body of sand the sewage passes through the material so quickly that under some conditions full purification is not accomplished. Whereas, in actual practice, with this same material and with under-drains many feet distant from each other the passage of the sewage through the greater bulk of the material would be much slower, and a better opportunity would be presented for the bacteria to convert the organic matter to harmless mineral matter. This point is well brought out (in a subsequent portion of this volume) by comparing the quality of the Framingham effluent obtained at the under-drain with that obtained at the spring.

It is during the winter months that the absence of lateral filtration in the case of experimental filters exerts its most marked influence, as has been already stated in explaining the relative deterioration of the quality of the effluents from the coarser Lawrence filters during the winter months.

VII. *Surface Treatment of Sewage Filters.*

The three most prominent lines of treatment which have been practised in the case of the Lawrence experimental filters — raking, scraping and spading (corresponding to ploughing) — are all capable of ready application on a large scale. The two methods, raking and spading, which have been found to be most advantageous, are capable of inexpensive application in the case of filter fields by the aid of the harrow and the plough.

With regard to the construction of trenches of coarse sand in filters of fine material there is reason to believe that this would be a decided advantage in some instances on a large scale, as has been the case with Filters Nos. 2 and 4.

The remaining point of importance concerns the protection of the surface of filters during cold weather. Owing to the marked influence of temperature upon the process of nitrification there is no doubt but that it has been an advantage to protect the experimental filters by means of canvas covers. From the experience at Framingham and Marlborough it appears that similar results on a large scale may be obtained by arranging the surface in alternate ridges and trenches. As has been stated in previous reports the trenches to which the sewage is applied are soon roofed by snow and ice, and in this way the portions of the material in which the purification takes place are protected from the winter weather, and the biological processes are preserved.

VIII. *Effect of Winter Weather.*

It has been pointed out that in order to obtain the best results in winter it is necessary to have the process of nitrification thoroughly established at the beginning of cold weather, to have the surface layers porous, and to take all practicable means to keep a high temperature and plenty of air in the filters, which must receive systematic treatment without too long an interval of rest.

So far as the completeness of nitrification and the porosity of filters in the late fall are concerned this can be done as well, under ordinary circumstances, on a large as on an experimental scale. With regard to the general operation during the winter the only point of importance to note is that when the rate of filtration is high the experimental filters have been kept porous in some instances by treatment which would be very expensive on a large

scale; and it would probably be more economical as a general rule to reduce the rate of filtration and increase the filtering area. By means of picking holes in the surface of the experimental filters it has been the quantitative and not the qualitative efficiency which has been increased. When the process of nitrification has become destroyed, or practically so, during the winter months it is impossible by ordinary means to re-establish thorough purification in either experimental filters or those in actual practice until warmer weather comes in the spring.

IX. Limitations of Experimental Filters and of Filter Fields in the Purification of Sewage.

From what has already been said in the last 50 pages of this discussion it is obvious that the capacity of a filter plant, experimental or otherwise, is determined by the amount of sewage which it can purify during the winter months. Two reasons for this are, the diminution in the activity of the nitrifying organisms, and the difficulty in keeping the surface porous so that sufficient air may enter the pores of the filter. All things taken into consideration it is believed that, as a general rule, the conditions under which the experimental results at Lawrence have been obtained are for the most part capable of adoption on a large scale in Massachusetts at a moderate cost.

It may be added here that all practicable means of removal of sludge from sewage, and of increase in the temperature, are advisable.

Filtration through Coke.

Filter No. 22 A. — This filter was filled March 19 with 5 feet in depth of fine coke breeze (screenings from commercial coke). The rate of filtration was 240,000 gallons per acre up to November 5, when it was increased to 360,000 per acre daily for six days in the week. The surface was raked 1 inch deep once a week from April 17 to June 1, after which it has been raked 3 inches daily. On April 3 about one-half inch was scraped from the surface, and 3 inches more were removed from the surface on November 14. The total depth removed up to January 1 was 3.5 inches, which is equivalent to 8.3 cubic yards per million gallons filtered. The average rate up to January 1 was 260,000 gallons per acre daily for six days in the week, and the average removal of organic matter (albuminoid

ammonia) and bacteria from the applied sewage has been 95 per cent. and 98 per cent. respectively.

These results indicate that in places where sand is not readily available a good substitute may be had in coke, which serves as a satisfactory *nidus* for the oxidizing and nitrifying processes. The greater porosity of the coke appears to be an advantage, for the rate of filtration has thus far been higher than has been obtained with sand under similar circumstances. One of the chief points in favor of coke, moreover, is that the portion scraped from the surface has not lost its value for fuel purposes, and the principal object hereafter of the present experiment will be to learn at how high a rate of filtration a well purified effluent may be obtained from a coke filter, the surface of which is systematically scraped.

Rapid Filtration of Sewage from which Sludge has been removed by Different Methods.

It is the sludge in sewage which causes the most trouble with respect to clogging, and interferes most seriously with the efficiency and permanency of filters. This is especially true in the case of land treatment during the winter months, as was referred to on page 531. The filtration of sewage after a preliminary removal of sludge was considered in the last report, and experiments have been continued with the use of the following methods of removal: —

1. Rapid filtration through coarse gravel, with the aid of a current of air drawn downward through the gravel.
2. Chemical precipitation.
3. Sedimentation.
4. Mechanical devices, of which straining through coke has been found to be the most satisfactory.

1. *Filters Nos. 15 B and 16 B.* — These filters with trapped outlets contain gravel stones 65 inches in depth, of an effective size of 5.1 millimeters. They have been in operation since July 25, 1892. It was noted in the last report that there was a leak in the outlet toward the close of 1893 which prevented perfect aeration by means of the aspirator. This caused clogging to such an extent that it was not overcome by spading to the depth of 1 foot, and on February 23 Filter No. 15 B was flushed out by applying city water under pressure from below. Flushing was also tried on Filter No. 16 B, but did not remedy the trouble, so on March 24 the gravel was taken out and washed with water from the hose. Since this time both

filters have done satisfactory work at the rate of 480,000 gallons per acre daily for six days in a week. The surface of each filter has been raked 3 inches deep once a week except during the month of March.

In July and August considerable suspended matter appeared in the effluent of No. 15 B, apparently due in part to the current of air which was constantly drawn downward through the material at the rate of about one gallon in four minutes. Beginning September 1 both filters have been aerated only at night, for about twelve hours daily, and better results from No. 15 B have followed. At the close of the year both filters were doing good work, but No. 15 B showed some signs of clogging. The results are summarized beyond.

Filter No. 21 A. — This filter originally contained 5 feet in depth of fine screened gravel like that in Filter No. 5 A, having an effective size of 1.6 millimeters. It has filtered sewage since March 19 at an average rate of 467,000 gallons per acre daily for six days in the week. The sewage has been applied in twelve doses of equal size at intervals of half an hour. Until August 1 the faucet on the outlet was closed during the day while the filter was being filled, and opened late in the afternoon, so that the sewage would drain out during the night at a rate not exceeding 2,000,000 gallons per acre daily. The outlet was trapped, and after August 1 the faucet has been kept constantly open. The frequent dosing caused considerable ventilation during the day, which, with a period of rest at night, enabled nitrification to become established. The rate, however, was too high for the degree of aeration, and beginning July 7 the filter has had a current of air drawn downward through it for ten to twelve hours each night at a rate of about one gallon in four minutes. This makes the experiment, with the exception of the size of the material, similar to those of Filters Nos. 15 B and 16 B. The surface was raked 1 inch weekly from April 17 to June 1, after which it has been raked 3 inches deep daily with the exception of August 6 and December 1, when it was spaded over 6 and 8 inches, respectively. The surface was scraped thirty-five times, June 7 to December 31, an average of once in six days. The average depth removed has been 0.18 of an inch, which is equivalent to 8 cubic yards per 1,000,000 gallons filtered. The rate appears to be too high to be permanently maintained, and it was necessary to allow the filter to rest during the first week in December.

2. *Chemical Precipitation.* — Sludge has been removed from sewage by treatment with sulphate of alumina at the rate of 1,000

pounds per 1,000,000 gallons, and the sewage allowed to settle for four hours. The results are presented beyond.

3. *Sedimentation.* — Sludge has also been removed from sewage by allowing it to settle for four hours, with the results given below.

4. *Straining through Coke.* — Beginning in June, sewage has been passed through coke supported by a thin layer of fine gravel. The depth of coke has varied from 1.5 to 8 inches, of which the latter depth is more satisfactory. The sewage has been allowed to pass through without any throttling at the outlet, and the surface is kept covered during the day, but allowed to uncover during the latter part of the night. The removal of clogged coke has been equivalent to about 5 cubic yards per 1,000,000 gallons treated.

In the table below, comparison is given of the removal of sludge by each of the four methods outlined. For a more complete description of these methods reference is made to pages 454, 455 and 456.

Table showing Purification of Sewage by Different Methods to remove Sludge.

Method.	Number of Filter.	Depth of Filter. — Inches.	Size of Gravel.		In Operation since —	Average Rate of Filtration. — Gallons per Acre Daily, Six Days in a Week.	Av'ge per Cent. Removed of —		
			Effective Size in Millimeters, 10 per Cent. Finer than —	Uniformity Coefficient.			Albuminoid Ammonia.	Oxygen Consumed.	Bacteria.
1. Rapid filtration through gravel, aided by a downward current of air.	15 B	65	5.1	2.0	July 25, 1892,	473,000	56	53	78
	16 B	65	5.1	2.0	July 25, 1892,	463,300	72	70	82
	21 A	60	1.6	2.4	Mar. 19, 1894,	467,000	89	87	96
2. Chemical precipitation.	-	-	-	-	-	-	57	50	68
3. Sedimentation.	-	-	-	-	-	-	30	21	15
4. Straining through coke.	-	-	-	-	-	-	52	44	43

Of these results, those obtained by rapid filtration are best, and they have the additional advantage of disposing of the sludge to a great extent, thereby avoiding a serious problem met with in precipitation and in sedimentation. The results obtained thus far from Filter No. 21 A are the best, in some respects, of those yet obtained at the station. It will be noticed also that very satisfactory results have been obtained by the use of coke as a strainer, and it should also be borne in mind that this treatment also disposes of the sludge question more satisfactorily than by methods Nos. 2 and 3, owing to the availability of the coke, after use, for fuel purposes.

In connection with land treatment of sewage and the great desirability of preventing surface clogging during winter weather, attention is especially called to a comparison of the results obtained by chemical precipitation and sedimentation.

The sewage after treatment by one of the several methods outlined above has been applied to filters 5 feet in depth, of medium fine sand, having an effective size of 0.17 to 0.19 millimeter, with results as follows: —

1. *Filter No. 12 A.* — This filter has received the effluent of Filters Nos. 15 B and 16 B at a rate of 960,000 gallons per acre daily for six days in a week. At the beginning of the year the gravel filters were so badly clogged that this filter became also clogged; and as the coarser filters were not in their normal condition, the effluent was not applied to No. 12 A from February 3 to 26. The surface was scraped when necessary, to remove clogging, up to June 19. It was scraped on an average once in seventeen days, and the average depth removed was 0.78 of an inch. This is equivalent to 12 cubic yards per 1,000,000 gallons filtered, — a quantity so large that scraping was abandoned, and since June 19 the surface has been raked twice weekly to a depth of about 3 inches. The filter was rested for one week from October 2 to October 8, and from October 27 to November 11, owing to overwork caused by sludge coming from No. 15 B. The surface was spaded 6 inches deep on September 6 and October 6, and 8 inches deep on November 27, and since that time it has taken the filtered sewage freely, with the results which are presented below.

2. *Filter No. 19.* — This filter has received sewage after treatment by chemical precipitation. The rates of filtration have been as follows: January 8 to May 21, 360,000 gallons; since June 1, 200,000 gallons per acre daily six days in the week. On March 10 clogging appeared at the old surface 4 inches below the present surface. The upper 4 inches of material were removed, the filter spaded to a depth of 6 inches, and 4 inches of new material added to take the place of that removed. The old and the new material were mixed together at the junction. The rate of filtration was too high, however, for satisfactory results, and after resting from May 21 to May 31 the rate was reduced on June 1. Up to this time the filter had been scraped to remove clogging fourteen times since January 8, an average of once in eight days. The average depth removed was 0.40 inch, equivalent to 18 cubic yards per 1,000,000 gallons filtered.

Since June 1 the surface has been raked twice weekly to a depth of 3 inches, with one spading over to a depth of 6 inches on December 1. The results are given beyond.

3. *Filter No. 13 A.* — To this filter has been applied sewage which has been clarified by sedimentation. The rate of filtration was 240,000 gallons per acre daily for six days in the week, from January 8 to May 21, when the filter was rested until June 1, after which the rate has been 160,000 gallons. From January 1 to June 1 the surface was scraped six times to remove clogging, an average of once in nineteen days. The average depth removed, 0.60 inch, equivalent to 18 cubic yards per 1,000,000 gallons filtered. Since June 1 the surface has been raked twice weekly to a depth of 3 inches. The results will be found beyond.

4. *Filter No. 14 A.* — To this filter, since June 1, has been applied sewage after straining through coke. The rate of filtration was 320,000 gallons per acre daily for six days in the week up to November 6, when it was increased to 480,000 gallons. The surface has not been scraped, but has been raked twice weekly to a depth of about 3 inches. The results are summarized beyond.

In the following tables are given the average analyses up to December 1 of the sewage before and after treatment by each of the several methods to remove sludge: —

Average Results of Analyses of Sewage before and after Treatment to remove Sludge.

[Parts per 100,000.]

	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Albuminoid.						
	Free.	Total.	Soluble.		Nitrates.	Nitrites.		
Original sewage,	3.43	.63	.26	8.07	.0000	.0000	3.54	1,330,000
After filtration through Nos. 15 B and 16 B,	1.03	.23	.11	7.76	1.3100	.0260	1.37	264,000
After chemical precipitation,	3.44	.27	.18	8.59	.0000	.0000	1.76	428,000
After sedimentation,	3.41	.44	.27	8.70	.0000	.0000	2.81	1,136,000
After straining through coke,	3.59	.30	.21	11.79	.0000	.0000	2.03	970,000

It will be seen from these analyses that the effluent of the sewage after filtration through Nos. 15 B and 16 B contains considerable nitrogen in the form of nitrates, and the free ammonia is much re-

duced. The establishment of nitrification in the preliminary treatment is of much aid in the filtration of this effluent by Filter No. 12 A. It may also be stated that the effluents from Nos. 15 B and 16 B contain considerable free dissolved oxygen, usually 25 to 30 per cent. of that necessary for saturation at the actual temperature. In the next table is given a summary of results obtained by the filtration of sewage through the fine sand after preliminary treatment by one of the several methods outlined in the foregoing pages.

Table showing Total Purification of Sewage by Filtration through Sand after a Preliminary Treatment to remove the Sludge.

Method of Preliminary Treatment before Filtration through Sand.	Number of Filter.	Depth of Filter. — Inches.	Size of Sand.		In Operation since —	Average Rate. — Gallons per Acre Daily, Six Days in a Week	Av'ge per Cent. Removed of –		
			Effective Size in Millimeters, 10 per Cent. Finer than —	Uniformity Coefficient.			Albuminoid Ammonia.	Oxygen Consumed.	Bacteria.
1. Rapid filtration through gravel, aided by a downward current of air.	12 A	60	.19	2.0	July 25, 1892,	700,500*	96	93	99.9
2. Chemical precipitation.	19	60	.17	2.0	Jan. 28, 1890,	253,000	96	93	99.8
3. Sedimentation, .	13 A	60	.19	2.0	Sept. 27, 1893,	184,600	95	94	99.8
4. Straining through coke.	14 A	60	.19	2.0	June 1, 1894,	345,000	97	94	99.9

* The rate during the period of actual operation of this filter was 960,000 gallons.

The very satisfactory results which have been obtained from filtration by the aid of a current of air drawn downward through the material by means of an aspirator, which have been reported upon since 1889, have been continued during the past year. It is now proposed to study the efficiency and economy of this method of combined filtration and renewal of the air in the filtering material upon a larger scale, with the operation of the plant covering from twenty to twenty-four hours each day. Aspiration has been used hitherto to increase the aeration of the material on account of the great convenience of this method, but it is now the intention to study comparatively the advantages of the renewal of air by blowing air into filters from below by means of a fan blower.

Work of the Filters for 1894.

The experimental filters used during 1894 for sewage purification have been mainly the ones which have been fully described in previous reports of the Board. Record of the temperature of the air during the past year has been given on page 526; while on page 457 will be found the record of the local rainfall. On the following pages is given an outline of the history of each filter and the monthly averages of the weekly analyses of the effluents. In order to make room for the new experiments in connection with the combined filtration and aeration of sewage, Filters Nos. 11 A, 17 A, 25, 30, 31 and 32 were discontinued at the end of the year, and partial summaries of the results of these filters will be found beyond.

Filter No. 1.

The surface of this filter of coarse sand of an effective size of 0.48 millimeter was in good condition at the beginning of the year, owing to the spading which it received on Dec. 2, 1893. The nitrifying and oxidizing processes had not wholly recovered from the effect of clogging late in the fall, and the ammonias in the effluent were high, although there was fair nitrification. The custom of picking holes in the surface daily to determine the depth of frost was abandoned for the reason that it aided in causing an unequal passage of sewage through the filtering area. Observations were made daily of the presence of frost which, on January 6, was found to vary from 3 to 9 inches in depth. From January 6 to 27 the sewage was applied always to the portion of the surface farthest removed from the under-drain. No trouble was experienced from frost so far as quantitative efficiency was concerned, but the qualitative efficiency failed to improve in spite of reduced quantities and resting every other day. In February the sewage was distributed carefully over the whole surface and the quantity applied restored on February 19 to the rate of 120,000 gallons per acre daily for six days in a week. The applied sewage disappeared readily, but it was not until the second week in March, when the temperature of the effluent increased to 42° F., that marked improvement of the effluent began to appear. It is of importance to note in the table beyond that

in January and February the quality of the samples of the effluent collected before the application of sewage and when the effluent flowed very slowly was much superior to that of the samples representing the entire flow and passing from the filter more rapidly. On March 31 the surface was spaded over (corresponding to ploughing) to a depth of 4 inches and the rate reduced on April 1 to 80,000 gallons per acre.

Fairly good results were obtained during the spring and summer, although high ammonias were found occasionally on account of the application of very strong sewage and also because of the occasional presence of small worms in the effluents. By putting a cap on the end of the outlet pipe and allowing the effluent to accumulate in the lower portion of the filter these worms were rapidly washed out and after a time they disappeared. In October the ammonias in the effluent increased and the sewage disappeared from the surface more slowly. From October 12 to 29 the filter was allowed to rest. The ammonias of the effluents were still high after this treatment and the filter was again rested November 4 to 30. On November 5 and 17 the surface was spaded over (corresponding to ploughing) to a depth of 8 inches. This additional period of rest did not cause the ammonias to decrease, in fact in December they increased while the nitrates decreased. The results from this filter, which are presented below as monthly averages of weekly analyses of the effluent, are discussed on page 485.

Effluent of Filter No. 1.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	49,000	47	38	1h. 40m.	Decided.	.65	1.6440	.1748	6.04	1.5300	.3960	.84	305,300
					Decided.*	.31	.8000	.0772	6.26	2.4600	.1780	.34	2,800
February, .	82,600	44	36	1h. 25m.	Decided.	.70	1.7450	.1435	5.62	1.3900	.0850	.95	113,500
					Slight.*	.29	.8467	.0640	5.56	2.6200	.1067	.56	15,933
March, .	120,000	46	42	5m.	Slight.	.40	.5180	.0830	7.22	3.1200	.1362	.62	56,200
April, .	80,000	46	45	2m.	Slight.	.27	.0243	.0404	6.50	3.8100	.0070	.29	42,700
May, . .	80,000	56	58	5m.	V. slight.	.15	.0281	.0309	8.94	5.1400	.0049	.29	11,600
June, . .	72,400	63	62	3m.	V. slight.	.15	.0087	.0369	10.29	3.3800	.0017	.21	6.200
July, . .	80,000	71	75	4m.	Slight.	.23	.1657	.0499	13.55	3.8100	.0127	.35	76,200
August, .	80,000	70	76	6m.	V. slight.	.13	.0144	.0231	11.98	3.6100	.0011	.17	27,400
September,	78,400	65	70	10m.	V slight.	.23	.0500	.0293	9.94	2.9300	.0010	.24	31,900
October, .	41,500	59	62	34m.	Decided.	.27	.2480	.0520	12.37	3.9000	.0037	.41	48,800
November,	7,600	52	52	45m.	–	–	–	–	–	–	–	–	–
December,	72,000	48	42	13m.	Decided.	.38	.7449	.0774	10.12	1.7400	.0197	.60	91,500

* Samples taken of effluent before filter was flooded on days of analysis of "regular" samples.

Sewage applied, 300 gallons six times a week from January 1 to January 15; 300 gallons three times a week, January 16 to 22; 300 gallons six times a week, January 23 to 29; 300 gallons three times a week, January 29 to February 2; 300 gallons twice on three days in a week, February 3 to 19; 300 gallons twelve times a week, February 19 to March 31; 200 gallons twelve times a week, April 1 to October 12; no sewage applied, October 13 to 27; 200 gallons twelve times a week, October 29 to November 3; no sewage applied, November 5 to 30; 100 gallons, December 1; 200 gallons, December 2, 4, 5; 200 gallons twelve times a week to December 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked about 1 inch deep each week except once in January, twice in December and during period of rest. Surface spaded 4 inches deep, March 31; 8 inches deep, November 5 and 17. June 18, July 6, 9, 13, 30, August 4 and 11, white worms found in under-drains and under-drains flushed out from below. During January, 13.5 inches of snow and .75 inch ice removed; during February, 20 inches of snow and .25 inch ice removed; during December, 20.5 inches of snow and 1.5 inches of ice removed.

Filter No. 2.

The trenches of medium fine sand of an effective size of 0.19 millimeter, present in this filter of very fine sand of an effective size of 0.08 millimeter, were relieved from clogging at the bottom and sides on Dec. 2, 1893, and were covered with boards until March 17. The applied sewage disappeared apparently without difficulty during the entire winter, and the quality of the effluent steadily improved. In the case of this filter of fine sand it is interesting to note, in the table beyond, that there was no difference in the quality of samples of effluent collected before flooding and during the height of flow. On March 31 the entire surface was spaded over (corresponding to ploughing) to a depth of 4 inches and the rate of filtration reduced April 1 to 40,000 gallons per acre daily for six days in the week, with a view to establishing a permanent rate. During the latter part of April the quality of the effluent became very satisfactory and excellent results were obtained until late in the fall. The only

important feature to note in the results obtained during this period is a decrease in the nitrates of the effluent during July and August owing to vegetation growing upon the surface around the trenches, as is described on page 493. Toward the end of November the free ammonia in the effluent increased quite rapidly and the sewage disappeared more slowly. On November 30 the sand was taken out of the trenches and replaced after removing a thin layer varying from one-eighth to one-half inch at the junction of the fine sand, and raking the bottom and sides to a depth of about 1 inch. In spite of this prompt treatment, however, the quality of the effluent failed to improve during the month of December. The results for the year are satisfactory on the whole, as is shown by the following table of monthly averages of weekly analyses of representative samples of the effluent: —

Effluent of Filter No. 2.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	60,000	45	37	1h. 35m.	None.	.08	.6260	.0332	6.35	2.1700	.1060	.28	2,500
					None.*	.08	.6260	.0332	6.35	2.1700	.1060	.28	2,500
February, .	54,600	44	36	3h. 15m.	None.	.06	.1416	.0230	5.76	2.3900	.0190	.21	370
					None.*	.06	.1416	.0230	5.76	2.3900	.0190	.21	370
March, .	57,800	45	40	2h. 30m.	None.	.06	.1035	.0200	4.90	2.1500	.0097	.17	162
April, .	40,000	46	43	20m.	None.	.06	.0382	.0179	7.04	3.1500	.0005	.17	1,075
May, . .	40,000	57	55	6m.	None.	.06	.0025	.0174	6.93	4.2900	.0000	.13	2,150
June, . .	37,000	63	59	8m.	None.	.05	.0017	.0130	6.60	3.1700	.0001	.10	1,150
July, . .	40,000	72	70	8m.	None.	.08	.0011	.0136	10.34	3.4900	.0005	.11	49
August, .	40,000	71	72	13m.	None.	.04	.0007	.0122	8.32	1.4100	.0000	.09	43
September,	40,000	66	69	20m.	None.	.04	.0003	.0111	11.80	3.6700	.0000	.10	15
October, .	40,000	55	62	40m.	None.	.07	.0005	.0114	9.35	3.2100	.0000	.10	7
November,	40,000	43	49	1h.	None.	.07	.0135	.0109	10.20	3.1200	.0008	.11	3
December,	37,000	44	40	4h.	None.	.07	.3170	.0245	7.47	1.9300	.0295	.23	6

* Samples collected before flooding.

Sewage applied, 300 gallons six times a week, January 1 to March 31; 200 gallons six times a week, April 1 to December 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Trenches covered with boards until March 17. Surface of trenches raked about 1 inch deep each week except with one omission in January, one in February and one in December. March 31, entire surface was spaded 4 inches deep. November 30, sand removed from trenches; bottom and sides of trenches scraped and raked; sand thoroughly mixed and replaced in trenches. August 15, grass on surface cut. March 1, 1 inch of ice removed from trenches. During November, 5 inches of snow and 0.25 inch of ice removed from entire surface. During December, 19.5 inches of snow removed from entire surface.

Filter No. 4.

The two trenches of coarse sand of an effective size of 0.48 millimeter, present in this filter of fine river silt of an effective size of 0.04 millimeter, were covered with boards until March 17. Sewage was applied to both trenches but it disappeared very slowly, usually during the night following the dose, and on January 22 both trenches were spaded over as well as the frost would allow to a depth of about 6 inches. This helped matters only for a short time, and on February 3 the rate of filtration was reduced from 30,000 gallons to 20,000 gallons per acre daily. It was necessary on February 26 to further reduce the rate to 15,000 gallons. During the latter part of March the sewage disappeared promptly, and on April 2 the rate was increased to 20,000 gallons and the entire surface spaded over (corresponding to ploughing) to a depth of 4 inches. The ammonias in the effluent increased during the winter and the nitrates remained low. During the spring and early summer the ammonias still increased while the nitrification became greater, although the increase in nitrates was somewhat irregular. In spite of the fact that the applied sewage disappeared readily a marked improvement of the qualitative efficiency did not occur until after July 18, when the sand was removed from the trenches, the sides and the bottom scraped from one-quarter to one-half inch, and raked about 1 inch in depth and the sand replaced. The effluent steadily improved in quality during the remainder of the year, and was very satisfactory in December, as is shown by the table below, containing the monthly averages of weekly analyses.

As was noted last year it appears from the evidence at hand that this filter of very fine silt is continually storing nitrogen, and its quantitative efficiency is becoming less year by year.

Effluent of Filter No. 4.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	26,600	44	40	14h.	None.	.14	.0146	.0246	6.11	.5700	.0004	.30	85
					None.*	.14	.0146	.0246	6.11	.5700	.0004	.30	85
February,	19,400	43	39	10h.	None.	.21	.1315	.0370	5.43	.4600	.0006	.47	108
					None.*	.21	.1315	.0370	5.43	.4600	.0006	.47	108
March,	15,000	46	42	2h. 20m.	None.	.28	.2475	.0410	4.97	.6200	.0020	.48	32
April,	20,000	46	44	3h. 40m.	None.	.42	.7400	.0540	5.61	.9300	.0054	.58	256
May,	20,000	57	55	1h.	None.	.62	1.2300	.0570	6.85	.8100	.0056	.64	743
June,	18,400	63	59	1h.	V. slight.	.45	1.4200	.0513	9.21	1.2200	.0137	.52	33
July,	20,800	72	69	30m.	V. slight.	.56	1.2080	.0476	8.76	1.0800	.0180	.72	22
August,	19,200	75	73	7m.	V. slight.	.42	.5300	.0290	8.76	2.1600	.0135	.50	26
September,	20,800	67	69	9m.	V. slight.	.37	.2067	.0227	10.18	2.3500	.0103	.37	11
October,	19,200	56	62	46m.	None.	.18	.0121	.0131	11.73	2.8300	.0035	.22	59
November,	21,600	45	51	2h.	None.	.12	.0022	.0099	9.15	3.2900	.0004	.15	52
December,	20,000	43	43	3h.	None.	.09	.0005	.0094	7.49	1.9900	.0000	.15	6

* Samples collected before flooding.

Sewage applied, 150 gallons six times a week, January 1 to February 2; 100 gallons six times a week, February 3 to 24; 75 gallons six times a week, alternately on inner and outer trench, February 26 to March 31; 100 gallons six times a week, on outer trench, April 2 to July 23; 200 gallons three times a week, on both trenches, July 24 to December 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Trenches covered with boards until March 17. Surface of trenches raked about 1 inch deep twice in January, once in February, three times each in November and December, and once each week during the rest of the year. January 22, trenches spaded 6 inches deep. April 2, trenches and fine sand in middle spaded 4 inches deep. July 18, sand removed from trenches. Bottom and sides of trenches scraped and raked and sand replaced in trenches. During January, ½ inch of ice removed from outer trench and 1 inch from inner. During February, 2.5 inches of ice removed from outer trench and 0.5 inch from inner. During November, 2 inches of snow removed from trenches. During December, 27.5 inches of snow removed from entire surface.

Filter No. 5 A.

This filter of fine gravel stones without sand, having an effective size of 1.40 millimeters, and unprotected from the weather, took sewage freely at a rate of 120,000 gallons per acre daily for six days in a week in two doses daily until February 24, when the temperature of the air was — 9° F. On this date the surface had not been raked for ten days and it was necessary to omit both doses on February 26 and one dose on February 27. Warmer weather followed and no further difficulty was experienced. The quality of the effluent was not satisfactory at the close of 1893, but it steadily improved during the winter months. On March 31 the surface was

spaded over (corresponding to ploughing) 4 inches in depth, and on April 9 the filter was restored to its ordinary depth by adding new gravel and by mixing it at the junction with the new material. Following this disturbance of the surface layers the ammonias in the effluent became higher and the sewage passed through so quickly that it was imperfectly strained and filtered. The nitrates, however, remained high. Good results for this filter of coarse material with such complete under-draining were obtained until the end of June. It was learned in tracing the passage of an application of salt that the sewage passed through the material very quickly, much of it within fifteen minutes, owing to the passage at a rapid rate through limited areas. As great care was taken to distribute the sewage equally over the entire surface, this difficulty seemed to be due to unequal storage of organic matter in the surface layers. With a view to removing this apparently unequal clogging, the surface was spaded over (corresponding to ploughing) 4 inches deep on July 13. This treatment caused but little apparent improvement in the ammonias in the effluent, as complications arose from the presence of worms. The nitrates were high during the entire summer. A series of samples, the results of analyses of which are given below, was taken on August 28, and indicated that the passage through the filter of the bulk of the sewage was too rapid for complete purification. To make sure that this was not due to the passage of sewage through limited areas caused by unequal clogging of the upper portion of the filter, the surface was spaded over (corresponding to ploughing) to a depth of 12 inches on September 4. The ammonias still continued high, indicating that the earlier results had not been caused by unequal porosity. On September 21 the size of the single dose was reduced one-half, — that is, sewage was applied at the rate of 80,000 gallons per acre daily for six days in a week, in eight doses daily, each equivalent to 10,000 gallons per acre. A decided improvement in the effluent followed this change which remained in effect until November 3. Up to October 20 the analyses of samples collected after the application of the sixth dose showed much better results as will be noted in the table beyond than were obtained from samples taken after the application of the first dose. The reason of this, doubtless, was that the first portion passed through too quickly for complete purification. After this time the sewage disappeared more slowly, and for the next few weeks, in fact, until clogging was removed by the

next spading, the analysis of the samples taken after application of the first dose was better than that of samples taken after the following doses. From November 5 to 16, the size of the dose was doubled, making a rate of 160,000 gallons per acre, but as the ammonias in the effluent increased the dose was reduced to the former quantity November 19 to 28. At the end of the month clogging appeared and on December 1 the surface was spaded over (corresponding to ploughing) to a depth of 6 inches. The application of sewage was changed from eight times 10,000 to two times 40,000 gallons per acre daily for six days in the week. There was no marked change in the quality of the effluent during December. In the table beyond are presented the monthly averages of the weekly analyses of the representative samples of the effluent.

Effluent of Filter No. 5 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	120,000	45	37	25m.	Decided. V. sl't.*	.72 .25	1.4440 .7440	.2332 .0752	5.71 5.69	1.2600 2.7100	.2520 .0078	1.16 .33	420,400 45,420
February,	115,000	42	37	1h. 10m.	Decided. V. sl't.*	.43 .12	.7325 .3900	.1052 .0493	5.87 5.71	1.9700 3.4700	.0069 .0043	.71 .27	104,600 1,530
March,	120,000	45	43	50m.	Decided.	.33	.1280	.0650	6.24	3.0500	.0051	.37	63,500
April,	80,000	47	46	1m.	Decided.	.65	.2160	.0855	6.64	3.1400	.0102	.61	110,000
May,	80,000	58	58	8m.	Slight.	.21	.1317	.0480	8.57	3.8200	.0217	.36	65,000
June,	71,600	64	63	7m.	Decided.	.22	.2208	.0502	9.54	3.2300	.0454	.32	58,000
July,	80,000	72	75	11m.	Decided.	.20	.3857	.0483	12.03	3.1000	.0048	.35	75,200
August,	80,000	70	75	6m.	Decided.	.24	.5350	.0610	12.36	2.5800	.0067	.44	105,500
September,	78,400	66	70	1m.	Decided.	.25	.4640	.1287	9.85	3.7500	.0157	.65	111,400
October,	80,000	56	61	17m.	V. sl't.	.14	.2960	.0356	14.20	3.2600	.0074	.21	11,200
November,	105,400	43	45	1h.	Decided.	.41	1.5800	.1060	9.85	1.4400	.0227	.70	96,000
December,	77,000	44	39	3h.	Decided.	.34	1.6350	.0870	8.46	1.4800	.0597	.60	48,200

* Samples collected before flooding.

Sewage applied, 300 gallons twelve times a week, January 1 to March 31; 100 gallons twenty four times a week, April 2 to September 20; 50 gallons forty-eight times a week, September 21 to November 3; 100 gallons forty-eight times a week, November 5 to 16; 50 gallons forty-eight times a week, November 19 to 28; 200 gallons twelve times a week, November 29 to December 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked about 1 inch deep each week except once each in January, November and December. March 31, surface spaded 4 inches deep; July 13, 4 inches deep; September 4, 1 foot deep, and December 1, 6 inches deep. April 9, filter restored to original depth and spaded 4 inches deep. On July 13, 30, August 4 and 11, outlet closed and effluent kept back to flush out under-drains. October 12 to December 31, effluent pipe trapped so that 1 foot above under drains remains saturated. During January, 20.5 inches of snow and 9.75 inches of ice removed; during February, 21 inches of snow and 9.5 inches of ice removed; during November, 4.5 inches of snow and 1 inch of ice removed; during December, 22 inches of snow and 0.75 inch of ice removed.

Table showing Results of Analyses of Samples of Effluent from Filter No. 5 A, collected at Different Periods of the Daily Flow.

[Parts per 100,000.]

1894.	Hour.	Rate of Flow. — Cubic Centimeter per Minute.	Temperature. — Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
Aug. 28,	8.37 A.M.	1,480	73	Decided.	.35	.5000	.0560	10.52	3.1200	.0100	.38	84,000
28,	1.25 P.M.	780	73	Slight.	.10	.0340	.0160	11.23	3.9800	.0004	.15	4,400
28,	2.21 P.M.	2,000	73	Decided.	.17	.1400	.0300	11.52	4.2900	.0014	.23	25,000

Table showing Comparison of Average Results of Analyses of Samples of Effluent collected from Filter No. 5 A after First and Sixth Doses during Different Portions of a Period between Spadings to show the Effect of Gradual Surface Clogging.

September 21–October 20.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed	Bacteria per Cubic Centimeter.
			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
After first dose, .	80,000	62	Slight.	.17	.4900	.0480	20.02	2.7200	.0049	.29	21,500
After sixth dose, .	80,000	62	V. slight.	.14	.1300	.0330	13.52	3.1500	.0128	.22	12,250

October 21–November 3.

After first dose, .	80,000	55	V. slight.	.12	.1650	.0150	10.05	3.0000	.0120	.16	1,050
After sixth dose, .	80,000	55	V. slight.	.11	.3950	.0290	9.69	2.8700	.0080	.20	16,100

Filter No. 6.

This filter, 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter, was protected from the weather by a canvas cover until March 17, and readily disposed of sewage through the winter at the following rates: January 1 to 27, 50,000 gallons per acre, in daily doses; January 30 to February 24, the same average rate with sewage applied every other day; and February 26 to March 31, 70,000 gallons per acre daily for six days in the week. The quality of the effluent was fair throughout the cold months, but the nitrites were very high and did not decrease rapidly until the middle of March, when the warmer weather restored to the organisms of nitrification their full activity. On March 31 the surface was spaded over (corresponding to ploughing) to a depth of 4 inches; and on April 1 the rate was reduced to 60,000 gallons per acre daily for six days in the week. The quality of the effluent quickly improved and remained excellent during the spring and summer. The ammonias and oxygen consumed increased for a short time in July owing to the application of sewage containing several times the usual amount of organic matter, the average amount of applied albuminoid ammonia for the week ending July 7 being 2.25 parts per 100,000.

About the middle of September the surface became clogged, and the filter was rested September 21 to October 8. The aid received from resting without disturbance of the surface was only temporary, and clogging reappeared during the latter part of October, while the effluent deteriorated in quality. The filter was again rested October 30 to November 30 and the surface spaded over (corresponding to ploughing) to a depth of 8 inches on November 8 and November 17. During December nitrification decreased, apparently owing to the diminution in the activity of the nitrifying organisms during the long period of rest, as described on page 510. In the following tables are presented the results of analyses of samples of the effluent collected before the application of sewage and at the height of flow during the winter months, and also the monthly averages of weekly analyses of representative samples of the effluent during the entire year: —

Effluent of Filter No. 6.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	48,200	44	38	13m.	V. slight.	.22	.1588	.0540	6.32	2.0900	.5000	.42	3,300
					V. sl't.*	.18	.1944	.0456	6.09	1.6300	.6300	.65	1,510
February, .	54,600	40	38	1h. 30m	V. slight.	.20	.0955	.0510	6.03	1.8200	.2175	.48	5,000
					V. sl't.*	.16	.1207	.0413	6.44	1.7800	.2700	.37	264
March, .	70,000	44	43	18m.	V. slight	.22	.1805	.0585	5.37	2.4600	.0762	.52	18,000
April, .	60,600	49	46	4m.	V. slight.	.19	.0268	.0539	6.31	3.2500	.0093	.35	2,800
May, . .	60,000	59	61	8m.	V. slight	.15	.0074	.0353	8.48	4.0100	.0560	.44	1,900
June, . .	53,000	66	65	6m.	V. slight.	.13	.0021	.0282	12.00	3.8500	.0003	.12	4,500
July, . .	60,000	74	75	12m.	None.	.11	.0333	.0368	19.60	3.7000	.0207	.25	1,900
August, .	60,000	72	76	25m.	V. slight.	.12	.0023	.0282	12.67	3.2000	.0007	.18	10,400
September,	38,400	68	69	4h. 35m.	Slight.	.38	.2623	.0616	12.53	5.2400	.0207	.51	37,500
October, .	40,000	54	57	12h.	V. slight.	.22	.2010	.0516	8.94	1.7100	.0547	.36	21,800
November,	0	-	-	-	-	-	-	-	-	-	-	-	-
December,	53,000	42	40	3h.	V. slight.	.23	.9900	.0616	9.51	1.4300	.1240	.62	10,800

* Samples collected before flooding.

Sewage applied, 250 gallons six times a week, January 1 to 27; 500 gallons three times a week, January 30 to February 24; 350 gallons six times a week, February 26 to March 31; 300 gallons six times a week, April 1 to September 20; no sewage applied, September 21 to October 8; 300 gallons six times a week, October 9 to 29; no sewage applied, October 30 to November 30; 300 gallons six times a week, December 1 to 21; 100 gallons six times a week, December 22 to 25; 300 gallons six times a week, December 26 to 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Filter protected with canvas cover until March 17. Surface raked about 1 inch deep each week, except once each in January, February and December. March 31, surface spaded 4 inches deep; November 8, 8 inches deep; November 17, 8 inches deep. During December, 20.5 inches of snow and 3 inches of ice removed.

Filter No. 7.

Sub-surface Application of Sewage. — This experiment was discontinued on July 7, it having been clearly shown that the oxidizing and nitrifying processes can take place under suitable conditions in filters to which sewage is applied beneath the surface. The chief feature of the method to be considered was found by this experiment to be the clogging of the sub-surface pipe in which the sewage was applied. A summary of the results of the investigation upon this subject was presented in the 1893 report, page 425. The results obtained in 1894 confirm the earlier conclusions.

The filter contained 44 inches in depth of mixed coarse and fine material of an effective size of 0.35 millimeter, above which were 10 inches of loam and 6 inches of soil. The sewage was applied in a circular pipe 6 inches in diameter and 18 inches below the surface with open joints every 2 feet. This pipe was clogged at the beginning of the year, and, during the continuance of the experiments in 1894, as much sewage was applied as the sub-surface pipe would hold. This quantity, however, was very small, ranging from 8,000

gallons per acre in February to 22,000 gallons per acre daily for six days in a week (calculated for the entire area) in May. Owing to clogging around the sub-surface pipe this quantity over-taxed the air capacity of the filter in June, and the ammonias increased while the nitrates in the effluent decreased. The quality of the effluent, on the whole, however, was very good under the circumstances, as is shown by the following table of monthly averages of the weekly analyses of the effluent: —

Effluent of Filter No. 7.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, . .	12,000	38	40	None.	.02	.0036	.0099	5.19	3.2000	.0000	.11	9
February, . .	8,000	38	38	None.	.02	.0027	.0106	5.18	1.2100	.0001	.13	6
March, . .	10,600	40	42	None.	.04	.0045	.0088	3.83	.7800	.0050	.10	72
April, . .	10,400	48	46	None.	.03	.0041	.0084	4.43	2.2900	.0003	.12	95
May, . . .	22,400	60	54	None.	.05	.0299	.0130	7.31	2.3100	.0001	.10	66
June, . . .	19,600	66	61	None.	.04	.1460	.0100	9.15	1.8600	.0004	.13	30

Sewage applied six times a week. June 25 to 27, experiment interrupted by breaking of sewer pipe. July 5, experiment discontinued.

Filter No. 9 A.

This filter, of medium fine sand of an effective size of 0.17 millimeter, unprotected from the weather, was not in a satisfactory condition at the beginning of the year owing to sub-surface clogging which occurred in the fall, and which was removed on Dec. 2, 1893. The quality of the effluent in January was considerably better than during the preceding months, but this was accomplished, apparently, by reducing the rate of filtration and by resting for a short time. During the period of resting, January 15 to 21, the frost increased in the sand so that the filter was less porous and nitrification no greater at the end than at the beginning of the month. In February, sewage was applied at a higher rate but the quality of the effluent deteriorated and did not show marked improvement until the first week in March. On March 31, the surface was spaded over (corresponding to ploughing) to a depth of 4 inches, and the sewage has been applied since April 1, except in the case of resting or interruption, at a rate of 80,000 gallons per acre daily for six days in a week. The work of the filter was very satisfactory during the summer and early fall. In October the ammonias in the effluent began to increase and the

sewage disappeared from the surface more slowly. The filter was allowed to rest October 13 to 27 without disturbance of the surface. This did not remedy matters; and the filter was rested again, November 3 to 30, and the surface spaded over (corresponding to ploughing) 8 inches in depth on November 5 and 17. The results obtained in December following the long period of rest were unsatisfactory with regard to the quality of the effluent, and it appears that the activity of the nitrifying organisms was lessened by the long period of rest. The work of the filter is shown by the following table of monthly averages of the weekly analyses of the effluent : —

Effluent of Filter No. 9 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	42,200	47	37	8h.	Slight.	.36	1.5680	.0792	6.72	1.7100	.0180	.49	25,000
					Slight.*	.30	1.5267	.0640	6.42	2.0200	.0163	.36	10,620
February, .	70,000	46	36	7h. 20m.	Decided.	.56	1.8580	.1080	5.64	1.1900	.0290	.79	45,800
					V. sl't.*	.31	1.1667	.0533	5.27	1.5900	.0022	36	20,330
March, .	120,000	46	42	1h.	V. slight.	.16	.1879	.0443	6.32	3.4000	.0105	.26	23,500
April, .	80,000	48	44	22m.	V. slight.	.11	.0159	.0269	6.31	3.5100	.0005	.19	3,900
May, . .	80,000	58	58	9m.	V. slight.	.08	.0082	.0197	7.62	4.0800	.0004	.13	504
June, . .	70,800	65	62	9m.	None.	.10	.0036	.0160	7.96	3.3900	.0003	.12	540
July, . .	80,000	73	74	5m.	None.	.08	.0096	.0200	9.53	3.6500	.0015	.18	507
August, .	80,000	71	76	19m.	None.	.05	.0004	.0163	12.46	3.2000	.0005	.14	217
September,	80,000	67	70	50m.	None.	.07	.0007	.0141	11.60	3.4300	.0003	.15	462
October, .	41,500	59	62	2h.	None.	.11	.0354	.0215	8.17	3.4800	.0012	.15	724
November,	6,200	52	57	–	–	–	–	–	–	–	–	–	–
December,	75,400	42	40	1h.	Decided.	.45	2.0900	.1095	7.22	.8500	.0247	.78	53,200

* Sample collected before flooding.

Sewage applied, 300 gallons six times a week, January 1 to 13; no sewage applied January 15 to 21; 300 gallons applied January 22; 600 gallons three times a week, January 25 to February 24; 600 gallons six times a week, February 26 to March 31; 400 gallons six times a week, April 1 to October 12; no sewage, October 13 to 28; 400 gallons six times a week, October 29 to November 2; no sewage, November 3 to 30; 400 gallons six times a week, December 1 to 21; 200 gallons six times a week, December 22 to 25; 400 gallons six times a week, December 26 to 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked 1 inch deep three times each in February and December; once each week, March 1 to October 31. March 31, surface spaded 4 inches deep; November 5 and 17, 8 inches deep. During January, 11 inches of snow and 1.5 inches of ice removed; during February, 32 inches of snow and 3 inches of ice removed; during November, 1.5 inches of snow removed; during December, 19.5 inches of snow and 2 inches of ice removed.

Filter No. 10.

This large tank, one two-hundredth of an acre in area, was filled in July with 5 feet in depth of mixed coarse and fine sand, like that in Filter No. 6, and having an effective size of 0.35 millimeter. No coarse material or under-drains were placed beneath the sand except directly above and around the outlet pipe. A partition extending 3 feet below the surface was placed in the sand separating that quarter of the surface which was farthest removed from the under-drains. To this quarter of the surface sewage has been applied since July 18 at the rate of 160,000 gallons per acre daily for six days in the week. Up to December 23 the sewage was applied in three doses a week, afterwards in six doses. The partition causes the sewage to pass downward for 3 feet and then it has a lateral movement through a distance of from 12 to 16 feet. The doses appeared to be too large for complete purification during the winter, although good results were obtained until severe winter weather began. In December, when the sewage was applied in an open trench dug in the surface to a depth of about 1 foot, the quality of the effluent rapidly deteriorated, as is shown in the following table of monthly averages of weekly analyses : —

Effluent of Filter No. 10.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
July, . .	160,000	75	76	5m.	None.	.11	.0460	.0080	32.10	3.0900	.0100	.17	21,000
August, .	160,000	72	76	13m.	None.	.06	.0551	.0136	12.11	3.3400	.0026	.12	8,500
September,	160,000	67	70	25m.	V. slight.	.09	.0667	.0152	14.88	3.7200	.0010	.16	2,000
October, .	160,000	56	63	30m.	None.	.09	.0154	.0142	9.92	3.5000	.0002	.13	1,500
November,	160,000	42	48	42m.	None.	.10	.0642	.0138	7.80	1.8400	.0035	.14	2,300
December,	160,000	40	38	2h.	Slight.	.24	1.7800	.0730	7.15	1.4500	.0287	.45	17,000

Sewage applied, 400 gallons three times a week, July 18 to December 23; 200 gallons six times a week, December 24 to 31. Surface to which sewage is applied raked 1 inch deep each week until December 22. October 20, weeds pulled and entire surface raked 1 inch deep. December 1, trench dug in the part to which sewage is applied. During November, 5.5 inches of snow removed from the surface to which sewage is applied. During December, 17 inches of snow and 0.6 inch of ice removed from trench.

Filter No. 11 A.

This filter was filled in April, 1892, with clogged material (mixed coarse and fine sand) which had been scraped from the surface of Filter No. 6, having an effective size of 0.35 millimeter. Aided by occasional aspiration, this filter of clogged material yielded a well-purified effluent in 1892 and 1893, as was shown by the results which were described and discussed in the annual reports for those years. The results obtained in 1894 have been satisfactory for the existing conditions, and confirmed the conclusions already presented in earlier reports. The only new feature of the experiment was the application from April 2 to 14 of sewage heated to 100° F. This treatment did not appear to affect the working of the filter to any marked extent, and from April 16 to May 2 the applied sewage was heated to 150° F. This temperature interfered decidedly with the bacterial activity and the nitrification fell off rapidly while the free ammonia in the effluent increased, as is shown by the analyses below. After discontinuing the heating of the applied sewage, the nitrates greatly increased. They decreased again in July and August while the free ammonia changed but little. This was owing, apparently, to imperfect ventilation caused by the large amount of stored organic matter in the upper layers of the filter. After spading over the surface (corresponding to ploughing) to a depth of 12 inches on September 1 the nitrates in the effluent increased, as is shown by the following table of monthly averages of weekly analyses of the effluent: —

Effluent of Filter No. 11 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	60,000	38	43	50m.	Decided.	.34	.0400	.0460	5.96	1.7300	.0030	.36	38,000
February,	60,000	35	42	1h. 15m.	Decided.	.30	.0530	.0590	5.69	1.4600	.0025	.51	69,500
March, .	60,000	40	50	45m.	Decided.	.49	.0950	.0680	5.13	1.8600	.0021	.44	49,000
April, .	60,000	127	47	45m.	Decided.	.59	.1365	.1160	6.47	2.0700	.0035	.65	293,000
May, . .	60,000	59	56	45m.	Decided.	.73	.8300	.1240	7.66	.7800	.0032	.70	120,000
June, . .	58,000	65	63	45m.	Decided.	.76	.7100	.0850	7.67	1.0400	.0040	.50	61,000
July, . .	60,000	75	71	15m.	Decided.	1.65	.6800	.0740	10.60	.7700	.0030	.56	25,000
August, .	60,000	71	72	35m.	Decided	.65	.7400	.0590	10.15	.6700	.0035	.47	52,500
September,	60,000	66	67	20m.	Decided.	.57	.4900	.0560	11.50	1.1900	.0040	.40	113,700
October, .	60,000	55	62	25m.	Decided.	.50	.4300	.0540	10.99	1.3700	.0040	.39	60,000
November,	60,000	43	44	20m.	Decided.	.52	.5000	.0520	12.39	1.0600	.0010	.72	52,500

Sewage applied, 3 gallons six times a week, January 1 to 27; 6 gallons three times a week, January 30 to April 29; 3 gallons six times a week, April 30 to November 8. April 2 to 14, applied sewage was heated to 100° F.; April 16 to May 2, to 150° F. June 26, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep each week. March 9, surface spaded 6 inches deep; September 1, 12 inches deep. November 8, experiment discontinued.

Filters Nos. 12 A, 15 B and 16 B.

Filter No. 12 A, containing 60 inches in depth of medium sand of an effective size of 0.19 millimeter, has received the effluent of Filters Nos. 15 B and 16 B at the rate of 960,000 gallons per acre daily six days in the week.

Filters Nos. 15 B and 16 B are filled to a depth of 65 inches with gravel stones of an effective size of 5 40 millimeters, and have purified sewage at the rate of 480,000 gallons per acre daily, aided by a current of air constantly drawn downward through the gravel by means of an aspirator at the rate of about one gallon in four minutes. Toward the close of 1893 the ventilation of these two filters was incomplete, as was noted in the last annual report, owing to a leak around the outlet. The result of this was that nitrification decreased rapidly and remained very low during January and February, while clogging appeared in each filter on several occasions. Filter No. 15 B was flushed out January 6 by applying city water under pressure from below. The aid received was only temporary, and on February 1 the surface was spaded over (corresponding to ploughing) to a depth of 6 inches. On January 31 No. 16 B was spaded over to a depth of 12 inches. There was no marked improvement in the quality of either effluent although the sewage disappeared rapidly, and on February 9 an iron pipe three-fourths of an inch in diameter was put into the middle of each filter, reaching from the top to within about 6 inches of the bottom. The lower end of each pipe was plugged and there was a series of perforations, one-fourth of an inch in diameter, near the end. The aspirators were disconnected from the filters at the bottom of the tanks and attached to the upper end of these pipes. There was so much organic matter stored in the filters that complete ventilation was not obtained. On February 23, Filter No. 15 B was flushed out again by applying city water under pressure to the outlet for six hours. Satisfactory results followed this treatment. Filter No. 16 B was rested February 23 to March 3 and was given a flushing similar to that given to 15 B, but of longer duration, on March 3 and 4. The quality of the effluent from this filter did not show improvement, however, and on March 24 the gravel stones were removed and replaced after washing with a hose. The surface of each filter was raked 3 inches in depth daily until February 23 and once a week after April 30.

Good results have been obtained from these gravel filters during the remainder of the year with the exception of those from Filter No. 15 B through June, July and August, when considerable sludge was detached from the stones and made its way into the effluent. This is apparent in the analyses for those months given in the tables beyond, where it will be seen that the free ammonia, soluble albuminoid ammonia and nitrates were practically normal at this time. It will also be noticed that the rate of filtration of Filter No. 12 A was lower than usual. This was caused by some of the effluent having been drawn over into the aspirator. To remedy this, the aspirators have been run only at night since September 1 for twelve to sixteen hours daily, and much better results have followed with regard to albuminoid ammonia. The nitrates have remained high and practically no effluent has passed through the aspirator. It is to be noted here, however, that in the case of Filter No. 15 B the sewage disappeared from the surface less readily in the month of December.

Filter No. 12 A became badly clogged early in January in consequence of the clogging of the gravel filters. From January 12 to 28 the effluent of Filters Nos. 15 B and 16 B was applied to the new Filter No. 14 A (see below), of same construction as No. 12 A, which was allowed to rest. On January 29 the effluent was again applied to No. 12 A, and in two days it was again clogged so that the effluents from Nos. 15 B and 16 B, while these filters were in such unsatisfactory condition, were allowed to run to waste, February 3 to 26. From February 27 to March 4, this filter received the effluent of Nos. 15 B and 15 C, the latter a new filter of similar construction to Nos. 15 B and 16 B. After the older filters, Nos. 15 B and 16 B, were flushed out and aerated so that nitrification was re-established in them, No. 12 A took both effluents without difficulty and gave an excellently purified effluent, as is shown by the tables of analyses beyond. The effluent of No. 15 C was not applied to Filter No. 12 A after March 4. Up to June 19 the surface was scraped when necessary to relieve clogging. The average interval between scraping was seventeen days and the average depth scraped 0.17 of an inch, equivalent to 12 cubic yards of material removed per 1,000,000 gallons filtered. This quantity was so great that the practice of scraping was abandoned and the surface raked to a depth of 3 inches twice a week. This gave satisfactory results even when

much suspended matter was discharged upon the surface with the effluent from Filter No. 15 B. The excessive amount of sludge was a factor in producing clogging at the surface in the early fall. To afford relief the surface was spaded (corresponding to ploughing) 6 inches in depth, September 6 and October 27, and 8 inches in depth on November 21. It was rested from October 2 to 8, and from October 27 to November 11, and was in excellent condition at the close of the year.

Filter No. 14 A.

This filter contains the original under-drains of Filter No. 14, above which are 60 inches of medium fine sand like that of No. 12 A and having an effective size of 0.19 millimeter. From January 12 to 27 it was used as a substitute for Filter No. 12 A and received the effluents from Filters Nos. 15 B and 16 B at the rate of 960,000 gallons per acre daily six days in the week. Five days after this new filter was put in operation the surface became clogged and was raked to a depth of 2 inches. Two days later clogging again appeared and the surface was raked 3 inches deep. This raking was repeated on the following day, after which it was necessary to spade the surface to the depth of 6 inches daily. The application of the effluent from the gravel filters was discontinued January 27, fifteen days after this substitute filter was put in operation. Analyses of the effluent are presented in the table beyond, where it will be noted that there was but little more nitrification on January 24 than existed in the effluent of Filter No. 16 B, and this was very possibly effected by the old under-drains, which were seeded with the organisms of nitrification. The free ammonia and oxygen consumed increased during the short duration of the experiment.

Filter No. 15 C.

This filter was constructed February 27 of new materials, consisting of the usual under-drains beneath 60 inches in depth of gravel stones of an effective size of 5.40 millimeters. Air was constantly drawn downward through the filter at the usual rate by means of an aspirator attached to an iron pipe of similar arrangement to those put into Filters Nos. 15 B and 16 B on February 9. The rate of filtration was 480,000 gallons per acre daily for six days in the week.

Up to April 30 the surface was not disturbed. After that time it was spaded once a week to a depth of about 6 inches.

This experiment was undertaken partly with a view to obtaining a substitute, if necessary, for Filters Nos. 15 B and 16 B, but as the efficiency of these filters became fully restored the experiment was discontinued June 1. The sewage on all occasions disappeared immediately, as will be seen from the table of monthly averages of weekly analyses. The quality of the effluent in May was very satisfactory. It is also instructive to note that nitrification began about April 25, eight weeks after the beginning of the experiment.

The results from this set of experiments are summarized and discussed on pages 536–541.

Effluent of Filter No. 12 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Filtered Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Effluent.*	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	372,000	41	45	3h.	None.	.25	.4000	.0433	5.72	1.4700	.0080	.29	2,500
February, .	114,000	40	44	2h.	V. slight.	.17	.0226	.0280	3.01	1.5200	.0012	.26	8,200
March, .	904,000	46	49	1h.	None.	.13	.0446	.0206	5.99	1.8100	.0008	.20	380
April, .	900,000	47	49	1h. 40m.	None.	.14	.0142	.0216	6.89	2.5100	.0007	.24	322
May, . .	910,000	56	57	1h. 40m.	None.	.18	.0017	.0218	6.91	1.8300	.0000	.23	289
June, . .	836,000	65	62	1h.	None.	.16	.0016	.0212	8.70	2.1200	.0000	.22	227
July, . .	850,000	70	72	50m.	None.	.16	.0013	.0187	10.88	1.9800	.0000	.23	205
August, .	794,000	70	71	1h. 20m.	None.	.13	.0014	.0201	13.99	1.8300	.0000	.20	297
September,	922,000	65	67	1h.	None.	.10	.0017	.0181	10.04	2.3700	.0000	.22	483
October, .	524,000	56	55	5h.	None.	.11	.0620	.0200	15.35	3.1900	.0009	.21	840
November,	520,000	42	44	1h.	V. slight.	.18	.0974	.0353	8.47	3.0000	.0061	.28	7,800
December,	760,000	42	45	1h.	None.	.21	.0019	.0335	8.08	2.1000	.0000	.31	840

* From Nos. 15 B and 16 B.

Effluent of Filters Nos. 15 and 16 applied thirty-six times a week, January 1 to 11; none applied, January 12 to 28; thirty-six times a week, January 26 to February 1; none applied, February 3 to 26; thirty-six times a week, February 27 to September 1; thirty times a week, September 3 to October 1; none applied, October 2 to 8; thirty times a week, October 9 to 26; none applied, October 27 to November 11; twenty-four times a week, November 12 to December 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep twice weekly after June 21. January 2, surface disturbed 8 inches deep; September 6 and October 27, 6 inches deep; November 2, 8 inches deep. Surface scraped, and washed sand from previous scraping generally replaced, on following dates: February 1, March 19 and 23, April 6 and 18, May 2 and 31, June 19 and (by accident) July 6.

Effluent of Filter No. 15 B.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan , .	480,000	38	42	2m.	Decided.	.91	1.5400	.2244	.1524	5.50	.1700	.0466	1.96	453,000
Feb., .	442,000	35	41	4m.	Decided.	.96	1.5300	.2615	.1685	5.68	.1300	.0019	1.60	252,000
Mar., .	480,000	40	46	0m.	Decided.	.70	.5875	.1370	.0955	5.71	1.4500	.0053	.88	162,500
April, .	480,000	48	48	12m.	Decided.	.78	.8875	.1510	.1065	6.88	.8400	.0110	1.01	196,500
May, .	480,000	59	57	5m.	Decided.	.58	.3080	.1930	.0852	6.98	1.6600	.0088	1.07	171,000
June, .	438,000	65	65	1m.	Decided	.56	.5800	.5380	.0855	7.58	1.7600	.0115	2.30	234,200
July, .	480,000	75	70	0m.	Decided.	.97	.9700	.6005	.0975	8.05	1.4800	.0347	3.44	298,700
Aug., .	480,000	71	70	0m.	Decided.	.65	.6725	.4460	.0925	10.37	1.6400	.0049	2.18	311,000
Sept., .	480,000	66	65	0m.	Decided.	.59	.8633	.2533	.0880	8.75	1.9300	.0422	1.44	149,800
Oct., .	480,000	55	56	0m.	Decided.	.80	1.4450	.1705	.1250	9.75	1.4400	.0120	1.20	540,000
Nov., .	480,000	43	43	0m.	Decided.	.95	2.3933	.2249	.1867	7.94	.9900	.0410	1.60	350,000
Dec , .	480,000	39	43	24m.	Decided	.57	.9767	.1513	.1347	9.82	1.4500	.1720	1.07	316,500

Sewage applied, 2 gallons seventy-two times a week. No sewage applied February 23 to 27. Flooded from below with city water and then drained, January 6 and February 23. June 25 to 27, experiment interrupted by breaking of sewer pipe. Filter aspirated continuously from January 1 to August 31, after which, aspirated 12 to 16 hours per day at night. Until February 9, aspiration was through hole near outlet pipe, after which date it was through a pipe, ¾ inch in diameter, driven through the filtering material nearly to the bottom. Surface raked 3 inches deep daily, until February 23; once each week, April 30 to December 31. Surface spaded 6 inches deep February 1.

Effluent of Filter No. 16 B.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
Jan , .	466,000	38	41	45m.	Decided.	.64	1.9140	.2636	.1536	5.55	.0600	.0162	2.07	302,000
Feb., .	400,000	35	40	8m.	Decided.	.48	2.3400	.3196	.1680	6.71	.0400	.0010	1.79	327,200
March,	420,000	40	46	0m.	Decided.	.79	.9050	.1405	.1110	5.63	.6900	.0037	.97	182,000
April, .	480,000	48	47	12m.	Decided.	.94	1.7550	.1605	.1370	6.85	.8400	.0250	1.10	207,200
May, .	480,000	59	56	1m.	Decided.	.43	.4268	.1056	.0800	7.22	1.8000	.0156	.60	187,000
June, .	440,000	65	66	0m.	Decided.	.47	.3400	.2160	.0615	7.27	1.9300	.0062	1.00	135,700
July, .	480,000	75	71	0m.	Decided.	.90	.3065	.1280	.0820	7.75	1.8400	.0072	.99	212,500
Aug., .	480,000	71	71	0m.	Decided.	.46	.3150	.2385	.0605	10.02	1.6200	.0177	.58	250,500
Sept., .	480,000	66	66	0m.	Decided.	.53	.7700	.1433	.0800	8.64	2.2000	.0937	.78	195,300
Oct., .	480,000	55	56	0m.	Decided.	.56	.8975	.1195	.0975	10.28	1.8400	.0057	.80	327,700
Nov., .	480,000	43	41	0m.	Decided.	.60	1.2167	.1587	.1267	8.22	2.2400	.0080	.96	281,400
Dec., .	474,000	39	41	1m.	Decided.	.51	.8133	.1680	.1147	8.78	1.4800	.0310	1.17	295,500

Sewage applied, 2 gallons seventy-two times a week. No sewage applied February 23 to March 5. Drained February 23. Flooded with city water from below March 2 and 3. June 25 to 27, experiment interrupted by breaking of sewer pipe. Filter aspirated continuously from January 1 to August 31; after which aspirated 12 to 16 hours daily at night. Until February 9, aspiration was through hole near outlet pipe, after which date it was through a pipe, ¾ inch in diameter, driven through the filtering material nearly to the bottom. Surface raked 3 inches deep daily, until February 23; once each week, April 30 to December 31. Surface spaded 1 foot deep, January 31. Gravel taken out, washed and replaced, March 24.

Effluent of Filter No. 15 C.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week	Temperature. — Deg. F.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
March, .	480,000	44	0	Decided.	.99	1.8725	.1790	5.63	.0240	.0008	1.17	169,000
April, .	480,000	45	0	Decided.	.91	2.8600	.2049	7.05	.2230	.0052	1.22	228,750
May, .	480,000	57	0	Decided.	.50	.7225	.1255	7.43	2.3100	.0492	.81	170,000

Effluent of Filter No. 14 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
Jan. 16, .	480,000	42	-	None.	.16	1.1200	.0480	4.31	.1500	.0040	.18	10,800
" 17, .	480,000	44	-	V. slight.	.10	1.4400	.0480	5.06	.0400	.0050	.29	54,000
" 24, .	480,000	44	-	None.	.10	1.6800	.0480	5.59	.2000	.0210	.35	1,600

Filter No. 13A.

This filter contains 60 inches in depth of medium fine sand of an effective size of 0.19 millimeter, and has received the supernatant liquid from sewage which has been allowed to settle without chemicals for four hours. The rate of filtration for 1893 was 480,000 gallons per acre daily for six days in the week, — a quantity which overtaxed the capacity of the filter, which was allowed to rest from Dec. 23, 1893, to Jan. 8, 1894. From this time until May 21 the rate of filtration was 240,000 gallons per acre daily for six days in the week. This rate also was found to be too great for complete purification, and after resting the filter from May 21 to 31, inclusive, it was reduced to 160,000 gallons per acre. From January 8 to May 21 the surface was scraped when necessary to relieve clogging and was not raked. It was scraped during this period six times, an average of once in 19 days. The average depth removed was

0.16 of an inch, equivalent to 18 cubic yards per 1,000,000 gallons filtered. Since June it has been raked twice a week to the depth of about 3 inches and very satisfactory results have been obtained, as is shown by the following table of monthly averages of weekly analyses of the effluent. The results are summarized and discussed on page 538.

Effluent of Filter No. 13 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	240,000	44	3h. 15m.	V. slight.	.18	.2169	.0435	5.22	2.7000	.0232	.24	12,250
February,	240,000	45	3h.	None.	.11	.0239	.0250	5.72	2.3500	.0018	.21	1,900
March,	240,000	48	1h. 20m.	None.	.11	.0046	.0258	5.82	2.5000	.0003	.13	1,800
April,	240,000	49	3h.	None.	.25	.3898	.0382	6.25	1.6000	.0039	.30	1,000
May,	151,000	57	2h. 40m.	Slight.	.26	.6824	.0445	8.14	2.4100	.0527	.49	5,200
June,	144,600	63	15m.	Slight.	.17	.1673	.0293	8.36	4.5700	.0045	.19	957
July,	160,000	70	13m.	None.	.11	.0091	.0273	12.31	2.6700	.0011	.19	745
August,	160,000	68	20m.	None.	.07	.0036	.0309	9.00	2.7100	.0005	.10	360
September,	160,000	67	14m.	None.	.10	.0098	.0269	10.25	3.1300	.0052	.16	1,400
October,	160,000	65	20m.	None.	.10	.0081	.0206	11.32	2.6500	.0006	.15	1,300
November,	160,000	44	41m.	None.	.12	.0170	.0199	11.65	2.4400	.0005	.18	2,600
December,	160,000	44	1h. 6m.	None.	.13	.0251	.0215	7.32	2.1700	.0006	.19	145

No sewage applied the two weeks preceding January 8; settled sewage applied, 3 gallons twenty-four times a week, January 8 to May 21; none applied May 21 to 31; settled sewage applied, 4 gallons twelve times a week, June 1 to December 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep twice each week after June 1; 4 inches deep January 19 and 24. Surface scraped January 16, February 2, 5, 23, March 15, April 5 and 28. Washed sand replaced after scraping, February 5, 23, March 15, April 5 and 28.

Filter No. 14 A.

This filter, containing 60 inches in depth of medium fine sand of an effective size of 0.19 millimeter, was constructed Jan. 12, 1894, and was used until January 27 as a substitute for No. 12 A, as is described on page 558. It was allowed to rest until June 1, since which it has received sewage which has been strained through coke. The depth of coke supported by a thin layer of sand in the strainer

has varied from 1.5 to 8 inches, as is shown in the foot-notes to the table of monthly averages of the weekly analyses presented beyond. A depth of 6 inches is preferable to that of 1.5 inches. It is estimated that the removal of clogged coke in the case of ordinary sewage would range from 5 to 8 cubic yards per 1,000,000 gallons strained. The rate of filtration was 320,000 gallons per acre daily for six days in the week up to November 6, when it was increased to 480,000 gallons per acre. This seemed to overtax the capacity of the filter and on December 26 the surface was spaded over (corresponding to ploughing) to a depth of 6 inches while the rate was reduced to 320,000 gallons per acre. The surface has been raked twice weekly to the depth of about 3 inches. It will be seen from the following table of analyses of the effluent that good results have been obtained from this method of purification. The results are discussed on page 538.

Effluent of Filter No. 14 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
June,	290,000	62	1h. 25m.	None.	.10	.2011	.0214	7.67	2.3500	.0267	.21	172
July,	320,000	70	10m.	None.	.12	.0008	.0151	14.35	2.3800	.0000	.17	121
August,	320,000	68	40m.	None.	.07	.0007	.0156	20.81	1.9800	.0000	.15	125
September,	320,000	67	7m.	None.	.06	.0014	.0190	9.19	2.5200	.0030	.18	242
October,	320,000	54	12m.	None.	.09	.0479	.0188	13.01	3.0400	.0150	.16	136
November,	456,000	44	25m.	None.	.15	.3720	.0260	8.40	2.6500	.0048	.29	2,000
December,	390,000	44	1h. 30m.	None.	.23	.6493	.0373	9.24	2.4300	.0097	.43	240

Four gallons of sewage, strained through 1.5 inches of coke and aerated 20 minutes, applied twenty-four times a week from June 1 to August 1; sewage applied without aeration and without straining, August 1 to 6; 4 gallons of sewage, strained through 1.5 inches of coke, applied twenty-four times a week, August 6 to October 18; 4 gallons of sewage, strained through 6 inches of coke, applied twenty four times a week, October 19 to November 5; 4 gallons of sewage, strained through 6 inches of coke, applied thirty-six times a week, November 6 and 7; 4 gallons of sewage, strained through 8 inches of coke, applied thirty-six times a week, November 8 to December 22; none applied December 23 to 26; 4 gallons twenty-four times a week, December 27 to 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep twice each week. December 26, surface spaded 6 inches deep.

Filter No. 17 A.

This filter contains 60 inches in depth of medium fine sand of an effective size of 0.17 millimeter, together with four layers of fine marble dust, about one-half inch in depth, and distant from the top of the under-drains 1, 3, 4 and 4.75 feet, respectively. It has received sewage to which sulphuric acid, equal to 49 parts of actual H_2SO_4 per hundred thousand, has been added. The rate of filtration has been 60,000 gallons per acre daily for six days in the week and the quality of the effluent, on the whole, has been satisfactory, as is shown in the table below of monthly averages of the weekly analyses of the effluent. The ventilation was incomplete, however, in November and December, owing to the organic matter in the upper layers and the quality of the effluent deteriorated.

Acid sewage had been applied to this filter since Oct. 26, 1890, and the results show conclusively that such sewage may be regularly purified by sand filters to which a small amount of limestone has been added in the upper layers in order to neutralize the acid. The treatment of acid sewage has been discussed in the annual report for 1891, and the later results have confirmed the earlier conclusions. The only additional point of importance to note is the disadvantage of placing the marble dust in horizontal layers because the ventilation is impaired after continued use, owing to the differences in capillarity of adjoining layers. The work of the filters by years is as follows: —

Table showing Yearly Averages of Results of Analyses of Effluent of Filter No. 17 A.

[Parts per 100,000.]

Date.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
1890,	56,300	53	.1553	.0197	5.75	1.5200	.0086	.13	100
1891,	56,600	53	.0121	.0139	6.51	2.4577	.0021	.16	5
1892,	59,700	54	.0113	.0142	7.95	2.4736	.0014	.17	20
1893,	58,500	54	.2776	.0330	8.32	2.5010	.0032	.28	360
1894,	59,700	54	.2992	.0210	8.37	2.9100	.0035	.20	260
Average,	58,200	54	.1511	.0204	7.38	2.3725	.0038	.19	149

Effluent of Filter No. 17 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	60,000	38	39	2 h. 40 m.	None.	.09	.0386	.0196	6.46	2.6400	.0007	.19	4
February, .	60,000	35	43	10 m.	V. slight.	.11	.2550	.0200	4.75	2.2300	.0006	.24	20
March, .	60,000	40	44	25 m.	Slight.	.11	.1290	.0250	4.17	2.1400	.0007	.20	4
April, .	60,000	48	45	25 m.	V. slight.	.13	.4750	.0290	5.96	2.6400	.0080	.27	159
May, . .	60,000	59	58	6 m.	V. slight.	.11	.0652	.0180	6.73	4.0400	.0040	.19	390
June, .	56,000	65	62	5 m.	V. slight.	.14	.0058	.0186	9.11	3.6900	.0002	.19	190
July, . .	60,000	75	72	5 m.	None.	.09	.0024	.0149	12.42	3.6300	.0001	.16	69
August, .	60,000	71	71	5 m.	None.	.08	.0015	.0141	8.35	3.0400	.0001	.11	7
September,	60,000	66	68	7 m.	None.	.11	.0006	.0124	10.82	3.2100	.0000	.15	40
October, .	60,000	55	57	12 m.	Slight.	.14	.0527	.0123	11.77	3.3100	.0004	.16	21
November,	60,000	43	44	1 h. 15 m.	Slight.	.11	.8650	.0320	11.98	2.6100	.0095	.21	5
December,	60,000	39	46	30 m.	None.	.15	1.6800	.0360	7.95	1.8000	.0180	.31	2,200

Sewage applied, 3 gallons six times a week. June 26, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep each week.

Filter No. 19.

This filter contains 60 inches in depth of medium fine sand of an effective size of 0.17 millimeter, and has received the supernatant liquid from sewage which has been allowed to settle four hours after treatment with sulphate of alumina, at the rate of 1,000 pounds per 1,000,000 gallons. During the latter part of 1893 the rate of filtration was 640,000 gallons per acre. This quantity overtaxed the filter, which was allowed to rest Dec. 23, 1893, to Jan. 8, 1894. The rate of filtration from January 8 to May 21 was 360,000 gallons per acre. This rate was found to be too high for complete purification and the filter was rested May 21 to 31, inclusive. Since that time the rate has been 200,000 gallons per acre. During the early part of March clogging appeared at the old surface 4 inches below the present surface, and on March 10 the upper 4 inches were removed, the next 6 inches spaded over and 4 inches of new material added to take the place of that removed. The old and new materials were mixed together at the junction. From January 8 to May 21 the filter was scraped to relieve clogging fourteen times,

an average of once in eight days. The average depth removed was 0.40 of an inch, equivalent to 18 cubic yards per 1,000,000 gallons filtered. Since June 1 the surface has been raked twice weekly to a depth of about 3 inches. In November clogging began to show itself again and on December 1 the surface was spaded over (corresponding to ploughing) to a depth of 6 inches. In the following table are given the monthly averages of the weekly analyses of the effluent. On page 539 a discussion of these results will be found.

Effluent of Filter No. 19.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
				Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	360,000	40	2 h. 25 m.	V. slight	.24	1.3125	.0570	5.06	1.6400	.0057	.32	5,100
February, .	360,000	38	2 h. 20 m.	Slight.	.17	1.4600	.0485	5.55	1.9900	.0016	.39	4,100
March, .	350,000	46	1 h. 30 m.	V. slight.	.18	.5452	.0398	5.92	2.2900	.0025	.24	7,400
April, .	360,000	47	1 h. 25 m.	V. slight.	.11	.2060	.0250	6.25	2.9800	.0022	.19	4,700
May, . .	228,000	58	1 h. 45 m.	V. slight.	.10	.6133	.0260	7.16	3.4200	.0015	.19	495
June, .	180,000	62	12 m.	None.	.11	.0396	.0201	8.25	2.8400	.0002	.17	151
July, . .	200,000	70	13 m.	None.	.10	.0163	.0189	10.39	2.4600	.0007	.17	33
August, .	200,000	68	20 m.	None.	.07	.0072	.0210	8.22	2.3300	.0003	.16	29
September,	200,000	67	12 m.	None.	.07	.0870	.0146	8.46	2.7800	.0006	.18	30
October, .	200,000	56	25 m.	None.	.08	.0974	.0141	12.71	3.4600	.0001	.16	59
November,	200,000	41	40 m.	V. slight.	.12	.6600	.0285	10.74	2.2000	.0655	.32	2,100
December,	200,000	40	1 h.	V. slight.	.15	.4667	.0253	6.83	2.2100	.1517	.31	641

No sewage applied the two weeks preceding January 8; chemically precipitated sewage applied, 3 gallons thirty-six times a week, January 8 to May 21; no sewage applied May 21 to 31; chemically precipitated sewage applied, 5 gallons twelve times a week, June 1 to December 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep twice each week after June 1; 6 inches deep on December 1. Surface scraped, and washed sand from previous scraping replaced, on following dates: January 16, February 6, 14, 21, March 2, 10, April 3, 10, 19, 26, May 1, 4, 9 and 16. Upper 4 inches removed, next 6 inches disturbed and 4 inches of new sand put on, March 10.

Filter No. 21 A.

This filter was constructed March 19, 1894, and contained originally, above the usual under-drains, 60 inches in depth of fine sifted gravel like that in Filter No. 5 A, and having an effective size of 1.60 millimeters. Sewage has been applied each day for six days in the week in twelve doses of equal size, at the rate of 480,000 gallons per acre. Until August 1 the faucet on the outlet pipe was closed during the day, while the filter was being filled, and opened late in the afternoon so that the sewage would drain out during the night at a rate not exceeding 2,000,000 gallons per acre daily. The outlet has been trapped and since August 3 the faucet has been kept constantly open. The frequent dosing caused considerable ventila-

tion during the day which, with a period of rest at night, enabled nitrification to become established. The rate, however, was too high for the degree of ventilation and beginning July 7 the filter has had a current of air drawn downward through it from ten to twelve hours each night at the rate of about one gallon in four minutes. This aeration has been attained by means of an aspirator attached to an iron pipe reaching to the bottom of the fine gravel and similar to the method employed in the case of Filters Nos. 15 B, 16 B, since February 9. The surface was raked weekly to a depth of 1 inch, April 17 to June 1, after which it has been raked 3 inches daily. From June 7 to December 31 the surface was scraped thirty-five times, an average of once in six days. The average depth removed was 0.18 of an inch, which is equivalent to 8 cubic yards per 1,000,000 gallons filtered. On August 6 the surface was spaded over to the depth of 6 inches. Clogging became quite marked the last of November, and the surface was spaded over 8 inches in depth on December 1, and the filter allowed to rest one week. This treatment afforded relief for the rest of the month. In the table below are given the monthly averages of the weekly analyses of the effluent. The results are summarized and discussed on page 538.

Effluent of Filter No. 21 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Average Number of Applications which Remained on Surface less than 30 Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
March, . .	520,000	40	45	12	Slight.	.18	1.6533	.0580	6.54	.0000	.0005	.36	66,300
April, .	480,000	48	49	11	Decided.	.45	3.4800	.1305	7.13	.0200	.0006	.69	107,500
May, . .	480,000	59	59	8	Decided.	.45	2.2880	.0948	6.15	.2900	.0322	.62	129,000
June, . .	438,000	65	67	3	Decided.	.75	1.9750	.1000	7.98	.2000	.0175	.71	86,200
July, . .	462,000	75	73	3	V. sl't.	.72	1.5300	.0680	10.61	.8500	.0381	.70	44,300
August, .	480,000	71	74	6	V. sl't.	.23	.0725	.0505	9.08	1.1400	.0067	.35	30,800
September,	480,000	66	67	3	V. sl't.	.29	.1023	.0422	11.77	1.2500	.0009	.34	29,300
October, .	480,000	55	56	2	None.	.16	.1244	.0290	10.92	3.2300	.0034	.22	9,400
November,	470,000	43	40	2	V. sl't.	.22	.4675	.0445	7.20	3.1000	.0118	.30	27,900
December,	380,000	39	41	3	Decided.	.47	.5250	.0900	8.14	2.1400	.0180	.63	70,000

Sewage applied, 2 gallons twelve times a day at intervals of one-half hour, 6 days in a week, March 19 to November 30 and December 8 to 31; no sewage applied and aspiration continuous, December 1 to 7. Faucet closed before first application of the day and opened after the last, until August 3, after which the faucet was partly open all the time. June 25 to 27, experiment interrupted by breaking of sewer pipe. Filter aspirated during the night 12-16 hours daily, July 6 to December 31. Surface raked 1 inch deep each week, April 17 to May 28; 3 inches daily, June 1 to November 30 and December 8 to 31; 6 inches deep, August 6; 8 inches deep, December 1. Surface scraped on following dates: June 7, 8, 9, 11, 12, 13, 19, 23, July 1, 6, 10, 13, 17, 20, 24, 27, 31, August 3, September 15, 18, 21, 26, 28, October 3, 10, 19, 23, 27, November 6, 8, 15, 23, 28, December 1 and 31.

Filter No. 22 A.

This filter was constructed March 19, 1894, and contained originally 60 inches of fine coke breeze (screenings from commercial coke) above the usual under-drains. The rate of filtration was 240,000 gallons per acre daily for six days in the week up to November 5, when it was increased to 360,000 gallons per acre. The surface was raked 1 inch deep once a week from April 17 to June 1, after which it has been raked 3 inches daily. On April 3 about one-half inch of material was scraped from the surface and 3 inches more were removed on November 14, making a total of 3.5 inches, which is equivalent to 8.6 cubic yards per 1,000,000 gallons filtered up to the latter date.

Nitrification became established about the middle of May, and a well-purified effluent was obtained until the latter part of November, after the rate had been increased. From the December results presented in the following table of monthly averages of the weekly analyses of the effluent, it appears that the rate of 360,000 gallons overtaxed the capacity of the filter, unless the practice of systematic scraping was resorted to. The results obtained from the filter are discussed on page 535.

Effluent of Filter No. 22 A.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
March,	240,000	40	48	3 h. 40 m.	None.	.08	1.4267	.0547	7.01	.0350	.0018	8.11	26,300
April,	235,000	48	49	1 h. 45 m.	V. slight.	.06	3.1600	.0470	6.01	.0020	.0013	.15	60,200
May,	240,000	59	58	20 m.	V. slight.	.08	1.8250	.0444	7.29	.3000	.0788	.42	52,200
June,	222,000	65	64	8 m.	V. slight.	.05	.1126	.0181	8.50	.7400	.0187	.10	29,700
July,	240,000	75	70	3 m.	None.	.08	.0126	.0133	12.37	1.4300	.0025	.13	24,900
August,	240,000	71	72	3 m.	None.	.13	.1400	.0175	18.94	1.5500	.0080	.11	10,300
September,	240,000	66	66	4 m.	V. slight.	.18	.1213	.0180	9.04	1.8400	.0020	.16	9,200
October,	240,000	55	56	5 m.	V. slight.	.25	.2180	.0276	12.85	2.6900	.0030	.17	8,700
November,	346,000	43	39	40 m.	V. slight.	.12	1.1300	.0315	9.05	1.9000	.0095	.22	16,000
December,	360,000	39	41	1 h. 10 m.	V. slight.	.22	1.9900	.0790	9.20	.8100	.0260	.41	19,500

Sewage applied, 6 gallons twelve times a week, March 19 to November 3; 6 gallons 18 times a week, November 5 to December 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked 1 inch deep each week, April 17 to May 28; 3 inches daily, June 1 to December 31. Surface spaded 6 inches deep December 1; 6 inches of coke removed November 14.

Filter No. 25.

In this filter there was buried, on Dec. 18, 1889, the carcass of a dog, weighing eleven and five-tenths pounds, above 5 feet of sand and loam and beneath 6 feet of sand, loam and soil, as was described in the Special Report on the Purification of Sewage and Water for 1890, page 689. City water has been applied during 1894 at the rate of 60,000 gallons per acre daily for six days in the week, except during the winter months, when the water froze to the surface on several occasions and it was necessary to omit some of the applications. The outlet has been trapped and during the last part of the year the effluent has contained smaller quantities of free and albuminoid ammonia than at any previous time. The odor and turbidity have not disappeared but have been less than during the preceding year. The effluent has been discolored by iron during the greater part of the year, showing the lack of sufficient oxygen. Variable numbers of bacteria in the effluent have been found, and it is to be noted that they have developed on gelatine plates very slowly and apparently were in a degenerated form. The work of the filter for the past year is shown by the monthly averages of the weekly analyses of the effluent in the following table, beyond which is a table containing the yearly averages of all analytical results.

Effluent of Filter No. 25.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, . .	35,600	39	35	Slight.	.22	.2300	.0160	.20	.0160	.0060	.05	390
February, . .	20,000	37	39	Decided.	.18	.2100	.0140	.22	.0080	.0040	.06	1
March, . .	58,000	39	42	Slight.	.12	.2500	.0120	.19	.0550	.0080	.07	800
April, . .	60,000	44	52	–	.14	.2500	.0180	.22	.0180	.0060	.07	6,500
May, . . .	60,000	53	60	Decided.	.16	.2400	.0150	.16	.0130	.0040	.06	200
June, . . .	60,000	60	64	Decided.	.12	.2000	.0080	.14	.0090	.0020	.05	8,000
July, . . .	60,000	69	75	Decided.	.17	.2000	.0060	.24	.0070	.0006	.48	400
August, . .	60,000	70	70	Slight.	.10	.2300	.0040	.29	.0080	.0004	.03	200
September, .	60,000	66	70	Decided.	.15	.1400	.0060	.38	.0080	.0002	.10	200
October, . .	60,000	60	54	Decided.	.12	.1300	.0060	.33	.0110	.0023	.10	100
November, .	60,000	50	38	Slight.	.10	.1200	.0060	.29	.0150	.0044	.11	3
December, .	53,000	43	42	Decided.	.30	.1000	.0060	.32	.0280	.0030	.07	55

City water applied, 3 gallons six times a week, except on a few days during severe winter weather.

Table showing Yearly Averages of Results of Analyses of Effluent of Filter No. 25.

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.		Nitrates.	Nitrites.		
1890,	5,000	5.8454	.5086	4.75	.1875	.0317	-	6,900
1891,	9,576	9.4480	.4500	.40	.0480	.0072	.97	39
1892,	42,200	1.7724	.0441	.25	.0390	.0056	.17	23,620
1893,	58,500	.3360	.0200	.22	.0230	.0021	.14	1,014
1894,	53,900	.1917	.0097	.25	.0160	.0037	.10	1,400

Filter No. 30.

This filter contains 30 inches in depth of coarse sand of an effective size of 0.48 millimeter, and has received sewage at the rate of 55,800 gallons per acre daily for six days in a week. Nitrification has been good throughout the year although the ammonias have been somewhat variable. With a view to lowering the free ammonia, the surface was spaded over (corresponding to ploughing) to a depth of 6 inches on March 9. This did little good, however, and on June 1 the surface was again spaded to a depth of 6 inches, and the filter allowed to rest two weeks. This treatment appeared to be of little value and in June it will be seen that the ammonias of the effluent were very high, doubtless on account of too rapid passage through the filter. Better results followed, however, as is shown by the following table of monthly averages of weekly analyses of the effluent. Following this table is another, showing the yearly averages of all analytical results from this filter.

Effluent of Filter No. 30.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	55,800	38	39	5 m.	Decided.	.41	.1840	.1100	5.21	2.1100	.0080	.60	105,000
February, .	55,800	35	37	5 m.	Slight.	.27	.1760	.0540	5.84	2.5700	.0021	.36	11,500
March, .	55,800	40	45	1 m.	Decided.	.22	.2000	.0500	4.77	2.3400	.0010	.44	44,000
April, .	55,800	48	50	1 m.	Slight.	.30	.1500	.0480	7.26	2.9000	.0018	.31	31,000
May, . .	55,800	59	59	1 m.	Slight.	.16	.3300	.0440	6.65	4.5700	.0006	.25	21,000
June, .	53,000	65	74	0 m.	Slight.	.21	1.0400	.0840	8.67	4.4000	.0014	.32	8,000
July, . .	55,800	75	71	0 m.	V. slight.	.15	.1500	.0280	11.10	4.1500	.0006	.23	7,000
August, .	55,800	71	69	0 m.	Slight.	.25	.2000	.0280	9.23	3.2300	.0006	.20	17,000
September,	55,800	66	68	0 m.	V. slight.	.17	.0840	.0200	10.23	3.6300	.0004	.20	8,000
October, .	55,800	55	62	0 m.	Slight.	.28	.0820	.0310	10.98	3.7300	.0000	.25	28,500
November,	55,800	43	38	1 m.	Slight.	.22	.2000	.0440	7.72	3.4900	.0040	.27	49,000
December,	55,800	39	42	2 m.	Slight.	.22	.1300	.0220	8.12	2.9500	.0004	.26	110

Sewage applied, 2 gallons six times a week, except June 1 to 14, when none was applied. June 26, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep each week. Surface spaded 6 inches deep, March 9 and June 1.

Table showing Yearly Averages of Results of Analyses of Effluent of Filter No. 30

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
1890, ...	54,400	56	.0267	.0165	6.54	1.5650	.0026	.11	8,440
1891, ...	53,800	56	.0509	.0219	6.81	2.4200	.0039	.17	5,900
1892, ...	56,600	56	.0719	.0564	7.80	2.6586	.0180	.44	41,200
1893, ...	55,100	53	.0997	.0624	9.26	2.8196	.0031	.39	29,400
1894, ...	55,600	54	.2438	.0470	7.98	3.3400	.0017	.31	27,400
Average, . .	55,100	55	.0986	.0408	7.68	2.5606	.0059	.28	22,500

Filter No. 31.

This filter contained 60 inches in depth of medium fine sand of an effective size of 0.17 millimeter, and received sewage at the rate of 55,800 gallons per acre daily for six days in a week. The applied sewage disappeared slowly in January and February, and on March 9 the surface was spaded over to a depth of 6 inches. There was no further trouble from clogging but the free ammonia was not so low as in former years. On June first the surface was again spaded over 6 inches in depth and the filter allowed to rest two weeks. Owing to the tank having become completely rusted out in places it was necessary to discontinue the experiment the first part of July before the effect of this treatment was fully learned. The monthly averages of the weekly analyses of the effluent are presented in the following table, beyond which are given the yearly averages of the results of analyses: —

Effluent of Filter No. 31.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	55,800	38	39	9h.	Slight.	.21	.3520	.0420	5.78	1.9600	.0050	.35	680
February, .	55,800	35	40	12h.	Slight.	.26	.5380	.0410	5.76	1.1000	.0013	.38	8,000
March, .	55,800	40	44	12m.	Slight.	.24	.4700	.0520	4.96	2.2500	.0040	.36	16,000
April, .	55,800	48	50	23m.	V slight.	.18	.1750	.0390	6.07	3.0200	.0022	.21	3,300
May, . .	55,800	59	59	8m.	None.	.12	.0540	.0200	6.94	4.7000	.0008	.15	4,000
June, .	27,900	65	73	2m.	V slight.	.17	.4800	.0400	7.95	5.8800	.0120	.25	17,000

Sewage applied, 2 gallons six times a week, except June 1 to 14, when none was applied. June 26, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep each week. Surface spaded 6 inches deep, March 9 and June 1. Experiment discontinued July 8.

Table showing Yearly Averages of Results of Analyses of Effluent of Filter No. 31.

[Parts per 100,000.]

Year.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week	Temperature. — Deg F.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.		
1890, ...	52,600	56	.0987	.0208	6.18	1.4013	.0255	.18	1,810
1891, ...	53,800	55	.0398	.0195	7.95	2.5646	.0011	.16	2,800
1892, ...	56,600	56	.0163	.0268	7.72	2.8941	.0006	.30	1,900
1893, ...	55,100	53	.0180	.0233	8.47	2.8028	.0004	.22	534
1894, ...	51,100	51	.3450	.0390	6.24	3.1500	.0042	.28	8,160
Average, . .	53,800	54	.1036	.0259	7.31	2.5626	.0064	.23	3,000

Filter No. 32.

This filter contains 30 inches in depth of medium fine sand of an effective size of 0.17 millimeter, and has received the supernatant liquid from sewage which has been treated by chemical precipitation as is described on page 454. In 1893 the rate of filtration was 446,400 gallons per acre daily for six days in a week. This quantity overtaxed the capacity of the filter, which was allowed to rest Dec. 3, 1893, to Jan. 8, 1894. From January 8 to May 21 the rate was 334,800 gallons per acre, — a quantity which necessitated very frequent scraping and which also caused the free ammonia in the effluent to remain high. During this period the surface was scraped twenty-one times to relieve clogging, — an average of once in six days. The average depth removed was 0.24 inch, equivalent to 24 cubic yards per 1,000,000 gallons filtered. The filter was allowed to rest May 21 to 31, inclusive, and since June 1 has received chemically purified sewage at the rate of 167,400 gallons per acre daily for six days in a week. No material has been scraped from the surface since June 1 but the surface has been raked to a depth of 3 inches twice weekly. The work of the filter is presented in the following table of monthly averages of weekly analyses of the effluent: —

Effluent of Filter No. 32.

[Parts per 100,000.]

1894.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. — Deg. F.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed	Bacteria per Cubic Centimeter.
				Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	334,800	38	2 h. 20 m.	V. slight.	.19	1.1685	.0570	5.07	1.7400	.0060	.33	12,500
February, .	334,800	37	2 h. 10 m.	None.	.13	1.0675	.0375	5.50	2.0100	.0162	.26	8,400
March, .	334,800	46	2 h.	None.	.11	.8575	.0400	5.92	3.1000	.1250	.35	2,900
April, .	334,800	48	2 h.	None.	.11	.4625	.0290	6.88	2.8300	.0875	.31	1,800
May, . .	210,600	59	2 h.	None.	.14	.8733	.0406	6.70	2.5500	.0700	.32	1,100
June, .	150,600	63	35 m.	V. slight.	.16	.2666	.0313	8.05	2.3900	.0320	.23	533
July, . .	167,400	71	30 m.	None.	.15	.2325	.0250	9.68	2.5900	.0004	.17	943
August, .	167,400	70	35 m.	None.	.10	.0978	.0183	9.02	2.1900	.0003	.15	3,000
September,	167,400	67	35 m.	V. slight.	.18	.5850	.0320	8.40	2.5000	.0027	.30	5,200
October, .	167,400	56	40 m.	Slight	.16	.5150	.0520	10.79	2.0100	.0020	.30	7,100
November,	167,400	41	45 m.	V. slight.	.15	.7375	.0425	7.93	1.5800	.0104	.29	2,300
December,	167,400	40	1 h. 25 m.	V. slight.	.17	.5900	.0387	7.11	1.9100	.0483	.36	10,500

No sewage applied the two weeks preceding January 8; chemically precipitated sewage applied, 2 gallons thirty-six times a week, January 8 to May 21; no sewage applied May 21 to 31; chemically precipitated sewage applied, 3 gallons twelve times a week, June 1 to December 31. Sewage aerated twenty minutes before application, June 1 to July 31. June 25 to 27, experiment interrupted by breaking of sewer pipe. Surface raked 3 inches deep twice each week. Surface scraped, and washed sand from previous scraping, replaced on following dates: January 12, 18, February 1, 6, 10, 21, March 3, 12, 19, 23, 29, April 4, 9, 12, 18, 24, 27, May 1, 4, 9, 14 and 19.

FILTRATION OF WATER.

The investigations of the Board during the past seven years upon the filtration of the Merrimack River water have shown conclusively that, under proper conditions, thoroughly satisfactory results, from a hygienic point of view, may be obtained by this treatment. This conclusion is now based on the results of more than thirty thousand bacteriological analyses in connection with the examination of thirty different experimental filters. To this information we are in a position to add the knowledge obtained from the results of the actual operation of the large filter of the water supply of the city of Lawrence (2.5 acres in area), as well as the results of experience from the filtration of large public water supplies in Europe. At this time it may be stated that the problem of the hygienic purification of sewage-polluted waters in Massachusetts by sand filtration centres for the most part around the two following points: —

1. The hygienic efficiency of filtration under those occasionally occurring conditions which are less favorable than the normal for the removal of disease-producing germs from water, with a study of methods of improvement thereof.

2. The further determination of the laws of filtration, whereby contaminated waters may be rendered hygienically safe with the greatest economy.

The experiments have been conducted during the past year along the same general lines as those described in earlier reports of the Board. The results obtained up to May 1, 1894, were presented in the twenty-fifth annual report of the Board, for the year 1893. In the following pages there are presented the results for the remainder of the year, after the method adopted in earlier reports, except that in the account of the individual work of each filter more attention is given to the periods of minimum efficiency in accordance with the statements above.

Two new water filters have been constructed in 1894, and careful studies made of those started during the latter part of the preceding year. In July connections were made with the Essex Company's canal by means of a twelve-inch pipe, the old pipe having become inadequate. This canal is used for distribution of the Merrimack River water for power purposes, and, as has been stated in former reports, contains substantially the same water as is found in the river above the city where is situated the intake of the Lawrence city filter. The scale upon which the experiments have been conducted can be best shown by the statement that on the average more than 60,000 gallons of Merrimack River water have been filtered daily.

Owing to complications from freezing weather, the small iron filter tanks Nos. 18 A–49 were not operated during the winter months of 1894, and upon starting these filters in the spring it was found that in some respects they resembled new filters. City (filtered) water was applied to several of the filters for some weeks following the resumption of operation in the spring. In the next chapter there are presented and discussed some interesting and instructive observations upon the changes in the composition of filters during a period of several months' rest, after draining, and also upon the filtration of the city water after it had already passed through the city filter.

The table on the next page contains a summary of bacterial results, but the averages include only those results obtained from the filtration of the Merrimack River water. They include all river water results after the filters had been operated ten days from the time when operations were resumed in the spring. Following this table is a brief discussion.

B. prodigiosus was applied to many of the filters for a considerable portion of the time, on account of the special value attached to the results of the application of this germ. The reasons why the results from the applications of this germ to water filters are so important have been explained in previous reports of the Board, as have been the methods by which the experiment is conducted. An outline of the plans followed in this work will be found beyond. These results are used farther on in the discussion of the several factors which influence the hygienic efficiency of water filtration.

Summary of Average Daily Bacterial Results obtained from the Experimental Filtration of Merrimack River Water, May 1–Dec. 31, 1894.

Number of Filter.*	Date of Construction.	Effective Size of Sand † — Millimeter.	Uniformity Coefficient.‡	Estimated Maximum Rate § (when Sand was new).	Depth of Material. — Inches.	Method of Operation.	Average Rate of Filtration. — Gallons per Acre Daily.	Average Number of Bacteria per Cubic Centimeter in		Average Percentage which Number of Bacteria in Effluent was of Number Applied.	Average Bacterial Efficiency.
								Applied Water.	Effluent.		
3 B, ...	Sept. 23, 1893,	0.23	2.3	43	60	Intermittent.	2,932,000	12,600	106	0.84	99.16
7 A, ...	July 20, 1894,	0.26	3.7	43	24	Continuous.	1,642,000	16,400	239	1.46	98.54
8 A, ...	Sept. 26, 1893,	0.23	2.3	43	60	Continuous.	3,107,000	12,600	99	0.78	99.22
18 A, ...	Sept. 17, 1889,	0.48	2.4	184	60	Intermittent.	4,870,000	15,800	163	1.03	98.97
33 A, ...	April 28, 1892,	0.14	2.2	16	60	Continuous.	1,945,000	15,800	59	0.37	99.63
38, ...	April 28, 1892,	0.20	1.6	32	20	Continuous.	2,900,000	19,900	37	0.18	99.82
41, ...	May 9, 1892,	0.14	2.2	16	60	Intermittent.	2,005,000	15,800	29	0.18	99.82
42, ...	Oct. 29, 1892,	0.20	1.6	32	10	Continuous.	2,927,000	19,900	105	0.53	99.47
43, ...	May 20, 1893,	0.26	3.7	53	60	Continuous.	4,740,000	15,800	184	1.16	98.84
44, ...	May 20, 1893,	0.29	2.7	67	60	Continuous.	7,370,000	15,800	110	0.70	99.30
45, ...	July 10, 1893,	0.23	2.3	42	60	Intermittent.	4,790,000	15,800	86	0.54	99.46
46, ...	Aug. 21, 1893,	0.29	2.3	67	12	Continuous.	2,353,000	19,900	75	0.38	99.62
47, ...	Sept. 9, 1893,	0.29	2.4	67	60	Intermittent.	6,345,000	15,800	192	1.22	98.78
48, ...	Sept. 9, 1893,	0.38	3.5	116	60	Continuous.	4,730,000	7,800	212	2.72	97.28
49, ...	Sept. 9, 1893,	0.38	3.5	116	60	Continuous.	9,700,000	7,800	178	2.28	97.72
50, ...	July 23, 1894,	0.48	2.4	184	60	Continuous.	4,785,000	15,800	391	2.47	97.53

* Filters Nos. 3 B, 7 A and 8 A are each $\frac{1}{200}$ of an acre in area, and placed out of doors, without protection from the weather; the remainder are each $\frac{1}{20,000}$ of an acre in area, and are placed within the buildings.

† The "effective size" of the sand grains means that ten per cent. by weight of the grains are finer than the diameter given.

‡ The "uniformity coefficient" is the ratio A to B when the values of A and B are such that sixty per cent. by weight of the material is finer than A and ten per cent. finer than B.

§ The "maximum rate" is the maximum quantity of water, expressed in million gallons per acre daily, which, at a temperature of 50° F., will pass through a filter of clean sand with no air in its pores, and with no suspended matter upon its surface when the acting head is equal to the depth of sand. (See Mr. Clark's paper, beyond.)

Upon comparison, in general terms, of the results given in the foregoing table with corresponding ones obtained in former years, we find that with such sands as have been used for filtration of water supplies, with rates of filtration much in excess of those in former experiments and reaching from 3,000,000 to 7,000,000 gallons per acre daily, an average removal of more than 98 per cent. of the number of bacteria in the applied river water. With coarser sands, furthermore, filtering from 5,000,000 to 9,000,000 gallons per acre daily, we find an average removal of more than 97 per cent. of the number of applied bacteria.

Attention is especially called to the expressions, "average percentage which number of bacteria in effluent was of number applied" and "average bacterial efficiency." The reason for these expressions is, that there is conclusive evidence to show that, of the number of bacteria found in effluents, a considerable portion always, and probably not infrequently all of them, have their origin within the filter or under-drains and do not pass through the filter from top to bottom. It may also be stated that there are strong reasons to believe that to the class of bacteria which have their immediate origin within the filter or under-drains and not in the applied water, the bacterium generally recognized as the specific germ of typhoid fever (*B. typhi abdominalis* of Eberth) and also *B. prodigiosus*, do not belong. Accordingly, the results of the determinations of the number of bacteria in the applied water and in the effluent of a filter do not give the percentage of applied bacteria removed, but rather the percentage which the number that failed to appear in the effluent was of the number of applied bacteria.

The latter and more accurate expression is used throughout this report; and, technically speaking, it is known as the "bacterial efficiency" of a filter. In the light of this explanation it readily follows that the true removal of bacteria by filtration, and especially the hygienic efficiency, or removal of disease-producing germs, is considerably greater than is indicated by the ordinary bacterial efficiency.

With the older filters of fine material, and operated at rates not over 3,000,000 gallons per acre daily, the bacterial efficiency has been fully as satisfactory as in former years.

With regard to the limits in rates of filtration and in coarseness of material, it may be stated that Filter No. 50, with sand of an effective size of 0.48 millimeter, and operated at a 5,000,000 gal-

lon rate, has been found to be more sensitive to sudden but to a certain extent necessary changes in the conditions of operation than the older Filter No. 18 A, of similar sand, but which has been in operation for about five years. Filters Nos. 3 B, 8 A, 43 and 45, each 5 feet in depth, have been operated at a 5,000,000 gallon rate, and have given results which on the whole have been satisfactory. Rates above this quantity have been found to be less likely to give uniformly satisfactory bacterial efficiency.

Investigations upon Changes in Composition of Water Filters, after Resting, together with the Results of Double Filtration of Merrimack River Water.

On Dec. 8, 1893, the operation of the small in-door water filters, after draining, was discontinued, owing to complications from freezing weather. These difficulties come from two sources, as was explained in earlier reports, as follows: —

1. Formation of channels at the sides of the galvanized-iron tanks during very cold weather, when the wet sand freezes and expands, while the galvanized iron contracts. Upon subsequent thawing the sand contracts and the iron expands, whereby channels are formed. This occurred to a greater or less extent in former winters in the case of all the small in-door filters during periods of very cold weather. With large filters in actual practice, or in the large experimental filters situated outside the station (Nos. 3 B, 7 A and 8 A), these conditions are not known to obtain.

2. Formation of channels in the upper layers of filtering material, due to escaping air which is liberated by the applied water (saturated at 32° F.), as it increases in temperature upon passage through filters placed in the warm building.

The several small filters, Nos. 18 A to 49, inclusive, remained out of service until May, and in some cases until July, 1894, owing to delay in securing an adequate quantity of Merrimack River water from the canal by means of a new and larger pipe. When these filters were again put in operation it was found, as already noted, that some very interesting and instructive changes had occurred in their action and in their composition. These changes, furthermore, relate to the chemical, biological and engineering phases of the process of filtration.

Chemical Changes in the Composition of Filters.

In the annual report of the Board for 1893, page 484, a table was given showing the amount of organic matter, calculated from the albuminoid ammonia, contained on Dec. 8, 1893, in the various filters, and based on the results of analyses of numerous samples of sand collected from the filters at different depths. It was learned in the spring of 1894 that a considerable portion of this organic matter had been nitrified during the period of rest of five months or more, as was shown by the fact that the first portions of effluent leaving the filters contained nitrogen, in the form of nitrates, in comparatively large quantities. The amount of nitrogen in this form varied considerably in the effluents of the various filters. On an average, however, it was equivalent to about 30 per cent. of the amount indicated by the analyses to be present in the sand in the form of organic matter, at the time when the operation of the filters was discontinued. The range of variation in the case of the several filters was from 14 per cent. in Filter No. 18 A to 60 per cent. in Filter No. 43. The full reasons for this variation are not clear, but it is to be noted that Filter No. 18 A was put in operation in 1889, while Filter No. 43 was constructed in 1893. It is quite possible that a portion at least of the organic matter accumulated during five years of service in Filter No. 18 A was of a nature less readily attacked by the bacteria of oxidation and nitrification, under the conditions which obtained during the period under consideration, than was the case in the latter and much newer filter, which contained less than half as much organic matter. Other factors doubtless exerted an influence, and it is worth mentioning that the temperature varied in different portions of the building where the filters were situated.

With regard to conditions other than the amount of stored organic matter, and of which we have more accurate knowledge, such as size of sand grains, depth of sand, method of operation, etc., there seemed to be no marked tangible relation to the amount of organic matter converted into nitrates during the period of rest. In a pair of filters of similar construction, but of which one had been operated continuously and the other intermittently, there was a noticeable discrepancy in the percentage of removal. The intermittent filter showed much less removal than its continuous mate. In another pair this difference was far less marked, while in a third pair, which had been longest in service, the removal of organic matter was prac-

tically identical. Owing to the varying removal by continuous as well as intermittent filters standing side by side, it cannot be concluded that the method of operation was a prominent explanatory factor. The results from the several pairs of filters (5 feet deep), however, are given as a matter of record, as follows: —

Continuous Filters.				Intermittent Filters.			
Number of Filter.	Date of Construction.	Average Amount of Stored Nitrogen Dec. 8, 1893.* — Parts per 100,000 by Weight of Dry Sand	Percentage of Nitrogen Removed.	Number of Filter.	Date of Construction.	Average Amount of Stored Nitrogen Dec. 8, 1893.* — Parts per 100,000 by Weight of Dry Sand.	Percentage of Nitrogen Removed.
33 A, .	April 28, 1892,	1.24	27	41	May 9, 1892,	1.36	28
43, . .	May 20, 1893,	1.12	60	45	July 10, 1893,	1.26	49
44, . .	May 20, 1893,	1.47	54	47	Sept. 9, 1893,	1.20	24

* The organic nitrogen was calculated as $\frac{14}{17}$ of the albuminoid ammonia doubled.

In this connection it is not to be forgotten that there is a considerable loss of nitrogen during the process of nitrification. The amount of loss is not accurately known, and doubtless varied with the different conditions. Judging from our experience with the filtration of sewage, the amount of nitrogen which escaped, probably to a large extent as nitrogen gas, would, perhaps, increase the above percentages of removal of organic nitrogen about one-third.

Physical Changes in the Composition of Filters.

It was noticed when the filters were put in operation in the spring that the frictional resistance to the passage of water was less than it had been before the period of rest. This was most noticeable, of course, in the upper portions of the filters, where the accumulation of organic matter was greatest. The reason of it appears to be due in part to the removal by nitrification of some of the organic matter (including bacteria in the zoöglœa stage) which forms the gelatinous film around the sand grains, and in part to the thorough drying of the surface layers. Each of these changes breaks up to a certain extent the adhesion between the different sand grains, thereby offering a more ready passage for the water through the interstices.

This observation is important from an engineering point of view, as it bears upon the consideration of frictional resistance of filters to

the passage of water, as is discussed in a paper beyond, by Mr. Clark. These physical changes are also intimately associated with biological changes, as is shown in the following pages.

Biological Changes in the Composition of Filters.

From a biological point of view the sand grains of a filter which is in efficient service not only furnish a resting-place for the ordinary bacteria which are mechanically detained, but they are also surrounded with films of gelatinous material apparently composed in part of bacteria in the zoöglœa form, and incapable of detection by the regular methods of bacterial cultivations. The changes effected in the organic matter, and probably in the zoöglœa, of these films by nitrification and drying have already been mentioned. At this point it is proposed to deal with the bacteria which are in a more active state, and capable of ready cultivation.

The determination of the number of bacteria found in the sand of the filters in the spring of 1894 showed that more were present in a majority of cases at that time than at the date of discontinuance of operation of the filters. This is well shown by the following comparative results obtained from Filter No. 33 A: —

Depth from Surface (Inches).	Number of Bacteria per Gram.		Depth from Surface (Inches).	Number of Bacteria per Gram.	
	Dec. 8, 1893.	April 30, 1894.		Dec. 8, 1893.	April 30, 1894.
0-¼, ...	767,000	1,120,000	12, ...	38,000	52,000
1, ...	228,000	600,000	24, ...	8,000	28,000
3, ...	40,000	230,000	36, ...	12,000	49,000
6, ...	76,000	100,000	44, ...	15,000	11,000

The significance to be attached to the higher numbers of bacteria found in the sand at the close of the period of rest is not so great as would appear at first sight; and it is quite possible that the bacterial growth which may have occurred was very slight. The reason of this probably lies in the fact that the bacteria are much more readily detached from the dry sand grains than is the case when the grains are wet and coated with a sticky gelatinous film.*

Numerous determinations were made at frequent intervals of the numbers of bacteria present in the first portion of effluent of the several filters after operations were resumed. These results showed on an average that, during the first eight hours' flow of effluent, 22

* Compare 1893 report, page 486.

per cent. of the number of bacteria found in the filters on Dec. 8, 1893, were washed from the sand. The variation in the results from the several filters was very marked, ranging from 6 per cent. in Filter No. 48 (5 feet deep) to 80 per cent. in the case of Filter No. 46 (1 foot deep). The actual numbers of bacteria coming from the sand and present in the effluents of these two filters during the first eight hours' flow averaged 7,700 and 132,000 per cubic centimeter, respectively. In parenthesis it may be added that the nitrogen present in the effluents as nitrates was determined at the same time, and it was found that the amount of nitrogen in this form reached more than 2.5 parts per 100,000 in some instances.

From the discrepancies in the bacterial contents of the first portions of effluents of filters standing side by side it would appear that the apparent increase in the bacteria found in the sand, as illustrated by the last table, should be associated not so much with the idea of growth as with differences in mechanical and physical conditions of the filters. But it is not to be forgotten that with some species of bacteria there may have been a marked growth, while in the case of other species there may have been a dying out. The facts which have been presented, however, are conclusive proof that there are present in water filters certain species of bacteria which possess the power of continuance of life in the filter after draining, and in the presence of nitrification, for a period of over seven months (December 8 to July 20).

Considerable attention was given to the species of bacteria which were washed from the sand of the various filters. Sufficient time was lacking in which to make a thorough study of the subject, but it is instructive to note that the predominating kinds of bacteria were those customarily met in the effluents of filters in regular operation.

Results of the Application of River Water to These Filters.

It has been already intimated that these filters resembled new ones in some respects when they were first put in operation, after the long period of rest. A portion of the filters were so situated that city (filtered) water could be applied to them. The result from this application will be described shortly. The remainder of the filters (seven) continued out of service until the latter part of July, when the new pipe from the canal was completed, and from that time until December 1 they regularly received the application of river water taken from the canal.

From a chemical point of view it was learned that these filters, after resting, gave in less than a week results which we have reason to believe were very similar to those which would have been obtained had the period of rest not occurred. The results obtained during the first day were very abnormal, owing to the large amounts of nitrates which were washed from the filters, as has been already noted. On the second day the nitrates were also quite high in the effluent of those filters which were operated at a comparatively low rate of filtration. This set of filters was put in operation July 19–23, and on July 26 chemical analyses of the several effluents and of the applied river water were made. The results obtained from these analyses, as well as those from the new Filters Nos. 7 A and 50, and also from Filters Nos. 3 B and 8 A (July 19), which had been regularly in operation since the preceding September, are presented in the next table: —

Results of Chemical Analyses.

July 26, 1894.

[Parts per 100,000.]

Number of Filter.	Date when Filter was started.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
	1894.										
18 A,* . .	July 23,	81	.25	.0052	.0134	.20	.026	.0002	.27	37	200
33 A, . .	20,	77	.19	.0006	.0068	.21	.027	.0012	.21	3	300
41,* . . .	20,	78	.19	.0006	.0082	.20	.028	.0000	.22	51	400
43, . . .	19,	80	.21	.0006	.0090	.21	.025	.0000	.27	15	300
44, . . .	19,	82	.20	.0010	.0098	.21	.028	.0000	.26	17	200
45,* . . .	20,	81	.22	.0008	.0104	.21	.027	.0000	.26	42	100
47,* . . .	20,	81	.24	.0002	.0088	.21	.027	.0002	.26	56	400
7 A,† . .	July 21,	79	.28	.0102	.0136	.23	.010	.0004	.27	56	300
50,† . . .	23,	81	.07	.0128	.0060	.22	.014	.0002	.20	56	6,400
Applied water,	–	77	.36	.0116	.0222	.18	.008	.0002	.34	70	4,800

July 19, 1894.

Number of Filter.	Date when Filter was started.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
	1893.										
3 B,* . .	Sept. 23,	76	.17	.0012	.0078	.21	.026	.0000	.20	74	44
8 A, . .	Sept. 26,	78	.13	.0006	.0064	.22	.022	.0000	.16	34	8
Applied water,	–	77	.34	.0088	.0168	.20	.007	.0000	.28	70	10,200

* Intermittent. † New filters.

From the results of these analyses it appears that in the case of Filter No. 18 A a period of three days, following the resumption of operation, was too short to enable the bacterial and other processes to become sufficiently established, whereby the filter could yield an effluent of normal chemical purity. A period of six days, however, in the case of the remaining filters which had been rested, sufficed for the production of effluents of normal chemical quality, except that in two of the six effluents nitrogen as nitrites was present. In corresponding periods with newly constructed filters, furthermore, there was exhibited far less progress in the establishment of nitrification.

While normal chemical purification of the river water was quickly obtained, practically speaking, at this season of the year and when the temperature was high, different results would have been obtained at other times of the year, particularly with a much lower temperature.

A little longer period was required before the filters yielded an effluent of satisfactory quality from a bacterial point of view. This period ranged from six to ten days, varying with the individual conditions. In a majority of instances, however, the length was nine or ten days. This is shown in the following table, in which are presented the average daily number of bacteria in each of the several effluents during the first ten days after the resumption of operation of the filters; together with these results the corresponding ones obtained from the new Filters Nos. 7 A and 50 are given for the sake of comparison.

Average Number of Bacteria per Cubic Centimeter.

Number of Filter.	Date when Started.	Day after Starting.									
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
	1894.										
18 A*, . .	July 23,	13,500	1,700	1,100	350	325	65	–	98	15	50
33 A, . . .	20,	9,700	1,300	–	800	600	300	400	800	–	10
41,* . . .	20,	5,500	1,800	–	400	500	500	250	200	45	–
43, . . .	19,	23,000	5,900	3,400	–	700	1,500	–	800	100	31
44, . . .	19,	39,500	10,200	3,400	–	1,100	400	800	300	500	50
45,* . . .	20,	10,000	2,200	–	600	400	600	500	300	50	–
47,* . . .	20,	36,000	5,300	–	2,200	1,000	700	150	200	53	–
7 A†, . . .	21,	9,200	–	3,200	1,300	100	200	600	–	–	700
50†, . . .	23,	16,000	2,000	3,100	5,000	3,600	1,850	–	8,300	4,600	2,400

* Intermittent. † New filters.

During this period the bacteria in the applied river water ranged from 1,300 to 8,900, and averaged 3,800, per cubic centimeter. Additional information will be found beyond, in the detailed account of the work of the filters.

Combining the chemical and bacterial evidence, we find that it was substantially ten days after the filters were put in operation, when the effluents first appeared to be of satisfactory, normal quality. This period would doubtless be much different under other conditions, but from the data at hand it appears that it was considerably shorter than in new filters of similar construction and methods of operation.

Results of the Application of City (Filtered) Water to These Filters. (Double Filtration.)

To the remainder of these small in-door filters, Nos. 38, 42, 46, 48 and 49, city (filtered) water was applied from May until the first of September. This treatment was practically a second filtration of the Merrimack River water, and some very instructive results were obtained from it.

Chemical Results. — The chemical composition of the city water improved somewhat during the four months, May to August, inclusive, as will be noted in the tables of analyses beyond in the section on "Lawrence City Filter." On an average, however, the composition for this period of the city (filtered) water, which was applied to these filters, was as follows: —

Average Results of Chemical Analyses of Lawrence City (Filtered) Water, May–August, 1894.

[Parts per 100,000.]

Temperature. — Deg. F.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.
		Free.	Albuminoid.		Nitrates.	Nitrites.		
62	.24	.0008	.0085	.22	.038	.0000	.21	58

After four days' operation the effluents of Filters Nos. 38, 42, 48 and 49 showed a well-defined improvement in their chemical qualities. With Filter No. 46, for reasons which are now not fully understood, the chemical quality of the effluent showed no improvement after four days of operation of the filter. After eleven and seventeen days of operation the chemical analyses showed a diminution in

the amount of organic matter and in the color of the water after filtration, but the nitrogen as nitrates was also lower in the effluent than in the applied water. It was not until the filter had been in operation thirty days that the effluent showed the effect of well-established nitrification.

The degree of chemical purification of the city water obtained by the second filtration varied considerably in the case of the several filters, and also during different portions of the period of operation in the case of each individual filter. We have already referred to the purification by the different filters at the beginning of this period, and will next consider the average results for the entire period, which are given in the next table. Time occupied in passage through the filter, whereby the several processes may effect the purification, is an important factor in the study of this problem, and for this reason the depths of material and rates of filtration are recorded: —

Average Percentages of Removal by Filtration of Chemical Constituents of Lawrence City Water (Second Filtration).*

Number of Filter.	Depth of Material. Inches.	Prescribed Rate of Filtration. Gallons per Acre Daily.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
38, ...	24	3,000,000	28	10	33	0	11‡	0	14
42, ...	12	3,000,000	24	0	7	0	5‡	0	14
46, ...	12	2,500,000	16	10	8	0	3‡	0	9
48†, ...	60	2,500,000	16	40	22	0	11‡	0	9
49, ...	60	5,000,000	16	30	17	0	11‡	0	9

* Organic matter introduced with the applied *B. prodigiosus* is taken into consideration.

† No 48 was operated intermittently during the first part of the period; with this exception the operation of the filters was continuous.

‡ Increase.

These results show clearly that for the entire period Filters Nos. 38 and 42 were more efficient than Filters Nos. 46, 48 and 49, conditions being equal, in the removal of color and that organic matter represented by the oxygen consumed. The reason of this is probably the difference in chemical composition of the filtering materials. In the discussion presented in the 1893 report, page 483, upon the removal of color by filtration, it was noted that there was a greater removal by those filters constructed in 1892 than by those constructed during the following year. To the former set belong Filters Nos.

38 and 42, the sand of which was taken from banks on the south side of the Merrimack River; while in the latter set are Filters Nos. 46, 48 and 49, as well as the Lawrence city filter, the sand of which came from Gale's Hill on the north side of the river. The results of mineral analyses of the two lots of sand were given with other data in the discussion referred to above.

It was also noted in the above-mentioned discussion that the power of removal of color by these two kinds of sand changed as the filters remained in service, and the removal by the two sets of filters gradually became more nearly alike. Without going too deeply into details, as the conditions of construction and operation of the filters and results of analyses are described and presented beyond, it may be stated that the results of analyses obtained in August, the last month in which city (filtered) water was regularly applied to this set of filters, agreed by no means with the averages for the entire period. This is brought out by the following table, in which the August results are presented in a manner corresponding to that adopted for the results of the entire period, as given in the preceding table.

Percentages of Removal by Filtration of Chemical Constituents of Lawrence City Water, August, 1894 (Second Filtration).*

Number of Filter.†	Depth of Material. — Inches.	Prescribed Rate of Filtration. — Gallons per Acre Daily.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
				Free.	Albuminoid.		Nitrates.	Nitrites.	
38, ...	24	3,000,000	31	167‡	11	0	3‡	0	15
42, ...	12	3,000,000	31	233‡	3	0	3‡	0	15
46, ...	12	2,500,000	31	100‡	13	0	6‡	0	15
48, ...	60	2,500,000	39	33‡	30	0	6‡	0	15
49, ...	60	5,000,000	31	33	21	0	3‡	0	15

* Organic matter introduced with the applied *B. prodigiosus* is taken into consideration.

† All filters were operated continuously.

‡ Increase.

From these results it is seen that the removal of color and of oxygen consumed (carbonaceous matter) was substantially the same in the case of each filter; while with regard to the ammonias in the effluents of Filters Nos. 42 and 46 (of same depth) the amount was proportionally lower in the case of the latter filter than was indicated by the results given in the first table. For a further discus-

sion of the influence of the chemical composition of sands upon their action as filtering materials, reference is made to Mr. Clark's paper, beyond.

Comparison of the results of the second filtration with those of the first are of interest, and for this purpose the following statement is made of the average results obtained from the direct filtration of the river water by these filters before the period of rest. The removal of color, albuminoid ammonia and oxygen consumed from the river water averaged about 35, 50 and 20 per cent., respectively.

While nitrification and chemical purification in this set of filters, to which city (filtered) water was applied, became established in practically the same time as in the case of the remaining filters, to which raw river water was applied, it was found that the behavior of the two sets of filters, with regard to the establishment of normal bacterial efficiency, was quite unlike.

Bacterial Results. — During the period May to August, inclusive, the number of bacteria in the city (filtered) water, which was applied to this set of filters, ranged from 35 to 180, and averaged 111 per cubic centimeter. In the case of those filters which received river water it will be remembered from the table on page 585 that in ten days or less the numbers of bacteria in the effluents became practically normal and constant (under 50 per cubic centimeter). With the filters under consideration the results were much different. In fact, it was not until the fourth week of operation, after the period of rest, that the number of bacteria in any of the effluents became as low as that in the applied city water. Furthermore, with Filter No. 42 a period of more than six weeks elapsed before the above-mentioned conditions obtained.

Another striking feature in the results obtained from this group of filters is the exceeding slowness with which the bacteria in the effluents decreased to low and constant numbers. As has been already noted, the bacteria in river-water effluents of filters operated under similar circumstances became practically constant in ten days; but in the case of the city (filtered) water effluents the bacteria decreased, speaking in general terms, throughout the entire period in question. This is shown by the following table, in which are presented the weekly averages of daily quantitative determinations of the bacteria in the several effluents for a period of fifteen weeks. Owing to the fact that the filters were not started on the same dates, each week's results do not correspond to the same period of time in

the case of the several filters. This is a matter of but little consequence, however, because there was practically no influence exerted by the slight differences in the numbers of bacteria present in the applied city (filtered) water.

Weekly Average Results of the Daily Determination of the Numbers of Bacteria per Cubic Centimeter in Effluents of Those Filters to which Lawrence City (Filtered) Water was applied.

May–August, 1894.

Week after Resumption of Operation.	Effluent of Filters Nos.—				
	38.	42.	46.	48.	49.
1,	27,600	3,700	32,140	2,900	14,750
2,	234	149	635	857	413
3,	125	180	271	166	63
4,	56	234	91	106	55
5,	25	431*	53	60	62
6,	33	141	36	47	49
7,	36	39	38	28	33
8,	36	30	56	20	20
9,	36	33	52	24	27*
10,	10	28*	26	14	12
11,	16	19	34	16	25
12,	13	19	19	14	18
13,	22	13	54	10	5
14,	10	17*	12	7	6
15,	8	9	19	20	13

* The surface of the filter was scraped to relieve clogging during the week covered by this result.

During the gradual and continued decrease in the number of bacteria in the effluents it will be noted that in very few instances did they become less than 10 per cubic centimeter; and in no case did an effluent contain less than 5 per cent. of the number of bacteria in the applied water.

Another feature of interest is that the removal of the clogged surface layers by scraping exerted apparently no influence upon the bacterial contents of the effluents. The surfaces were not clogged by silt and organic matters, as is the case with filters which receive river water, but largely by iron rust and accumulations washed from the service pipes. This was remedied in part by the replacement in July of a portion of the old pipe with a new one. The material re-

moved by flushing from the old pipes, which had been in place for many years before the city water was purified by filtration, contained many living bacteria, which doubtless were of a very hardy nature.

Taking into consideration the chemical composition of the applied water, with its lessened amount of organic matter after passage through the filters, owing to nitrification, and the presence at the upper surface of the sand of a clogging layer, the question naturally arose, Are the bacterial contents of the effluents, higher than that of the applied water for nearly a month after the filters were put in operation, to be regarded as an indication of an abnormally low power of the filters to remove the applied bacteria, or are these results chiefly if not wholly due to the continuance of life and growth of certain bacteria within the filters and their under-drains?

Owing to the marked similarity between the species of bacteria in the effluents and in the applied city (filtered) water, it was decided, in order to obtain light upon the above question, to resort to the application of *B. prodigiosus*, according to the methods described in earlier reports. From July 6 to August 18 pure cultures of this germ were applied with the following results to Filters Nos. 46, 48 and 49: —

Weekly Average Results of the Daily Determination of the Number of B. Prodigiosus per Cubic Centimeter in the Applied Water and in the Effluents of the Several Filters, July 6–Aug. 18, 1894.

Week Ending—	Applied Water.	Effluent of Filters Nos.— 46.	48.	49.
July 7,*	7,800	24	58	41
14,	13,200	104	61	63
21,	15,200	84	44	40
28,	14,300	37	23	34
Aug. 4,	16,000	17	20	23
11,	11,100	8	11	22
18,	9,600	3	8	14

* Two days only.

By these results it is seen that the percentage removal of the number of applied *B. prodigiosus*, a germ apparently incapable of growth within these filters and their under-drains, was much greater than in the case of the applied water bacteria. Nevertheless, the most important lesson to be learned from the above-described experiment

is that the filters did not give at any time a normal efficiency in the removal of this germ, as is shown by the fact that the numbers in the effluents were about ten times higher than were ordinarily obtained from these filters and others of similar construction and operation in the filtration of river water during former years.

The information obtained from the application of river water and city (filtered) water to this set of filters, which remained out of service during the winter and early spring, points, with other evidence, to the following conclusion: An important feature of sand filters, which show normal efficiency in the removal of bacteria, consists of a gelatinous film around the grains, to a considerable depth from the surface, whereby the bacteria are mechanically detained there under such conditions that their lives come to an end.

Relative Degrees of Bacterial Purification of Water by Sand Filtration under Different Conditions.

The present report is the fifth in which an account of the Lawrence investigations upon this subject is given, and the third one that contains a discussion in considerable detail.

General Features of the Investigations.

At the outset of this discussion it is desired to call attention to some of the general features and conditions of the investigations under consideration. The most important of these are as follows: —

1. *Bacterial Methods.* — In the annual report of the Board for 1891, page 620, it was stated that unusual care was taken to make the bacterial determinations under conditions as nearly parallel as possible, in order that the results might be strictly comparable. Composition and reaction (optimum) of culture media and temperature and period of bacterial development have been controlled as carefully as possible. At this time the subject of methods will be dismissed, with the remark that it has been the custom in this laboratory to allow the bacteria present in the waters to develop in cultures for a period of four days at 20° C. In many laboratories the period is a somewhat variable one, and averages perhaps about forty-eight hours. On account of different but improved methods, the numbers of bacteria found in the Lawrence effluents have been considerably higher than would otherwise be the case.

2. *Bacterial Results of Filtration.* — There are several expressions which are used in speaking of the bacterial results of filtration.

Accurately speaking, their true significance is quite unlike, and considerable confusion has arisen from failure to clearly understand the differences. For the sake of greater accuracy and clearness it is proposed to give to these technical expressions a definite significance, showing the light in which they are now regarded at the station. The principal expressions in question are as follows: —

A. Bacterial efficiency.

B. Bacterial purification.

C. Hygienic efficiency.

Bacterial efficiency is regarded as the percentage which the number that failed to appear in the effluent is of the number of bacteria in the applied water. (Compare page 578.) It is this expression which truly applies to the results of the ordinary determinations of the number of bacteria in the applied water and in the effluent of a filter. The number of bacteria found in an effluent includes, as was noted on p. 578, those which had their origin in the lower portions of the filter and its under-drains, as well as those which may have passed directly through the filter from top to bottom. And there exist no well-defined methods by which these two classes of bacteria may be readily separated, under ordinary circumstances. Nevertheless, repeated determinations of the bacterial efficiency of a filter by a well-trained bacteriologist are perhaps the best index of the real work done by a filter.

Bacterial purification is regarded as the percentage removal by filtration of the applied bacteria. This expression bears no relation to those bacteria in effluents which have their origin within the filter or under-drains, and does not distinguish between the different kinds of bacteria which pass directly through the filter. As follows from the explanations above, there is no ready means of learning the true bacterial purification of filtration, and this is the reason why the artificial application of cultures of *B. prodigiosus* has been resorted to so regularly in studying the laws of filtration. It will be remembered from earlier reports that this particular species of bacteria has been found to be unable to grow within the Lawrence filters.

Bacterial purification signifies a greater percentage, of course, than does bacterial efficiency. Thus, in 1893, when *B. prodigiosus* was regularly applied to a set of filters which varied widely in their construction and operation, it was found that on an average the bacterial purification (*B. prodigiosus* results) was 99.81, while the bacterial efficiency was only 98.46. Many of these results were

obtained under very severe conditions, and it may be added that normal bacterial purification by filtration ranges, according to our present results, from 99.90 to 100.

Bacterial purification was the heading of corresponding sections in the two preceding reports, where the *B. prodigiosus* results served as a basis of discussion. The same heading is retained for the present section, largely for the sake of uniformity, although most of the data for the past year are upon bacterial efficiency, which calls for a change in the sub-headings. The consideration of the *B. prodigiosus* results as indicative of average bacterial purification assumes, of course, that the *B. prodigiosus* has substantially the same life history in water as the average germ which is found in the applied water, and which is incapable of growth within the filters.

Hygienic efficiency is regarded as the percentage removal by filtration of the applied bacteria that are capable of producing disease. The data at hand indicate that hygienic efficiency is at least as great as bacterial purification; and there are strong grounds for the belief that the removal of disease germs, under conditions which should obtain in actual practice, is greater than the removal of all bacteria for which water is the natural habitat, but which fail to grow within the filters.

The question of hygienic efficiency of filtration in a great majority of cases is the vital one to be considered. The subject cannot be definitely settled, however, until we have more accurate knowledge of ordinary water bacteria, and especially more detailed and exact information with regard to their life histories under different natural conditions. From the outset of the Lawrence investigations these problems have been a prominent feature of the biological work, and much light has been obtained upon them.

3. *Size of Filters.* — It is worth noting that at the present time we have results from the operation at all seasons of the year, not only of filters 20 inches in diameter but of those of 17 feet diameter, as well as of the Lawrence city filter, 2.5 acres in area. There is no evidence pointing to abnormal results from the small filters, except in those instances of which special mention has been made, and then the abnormal results have not been included in the averages arranged for discussion.

4. *Length of Service of Filters and Duration of Experiments.* — As the accumulation of facts bearing upon the best methods of purification of water continues year by year, it has been found that each

year's results are by no means a simple confirmation of earlier ones. With increasing age in filters come changes in their conditions, from which arise different degrees of bacterial purification, and which call for different management in their operation. Bearing this in mind, and also the fact that in actual practice plants for the purification of water are ordinarily constructed for permanent use, it is obvious that from a practical point of view the conclusions drawn from the results of a few weeks' or a few months' experimentation with new water filters are only of limited value and importance.

In this connection it is proper to point out to the reader that of the sixteen filters which have been studied during the past year, one was constructed in 1889, four in 1892, nine in 1893 and two in 1894. Careful records have been kept, showing the history of each filter in its several phases. Practical results of much value have resulted from the continuance of the investigations upon the same filter, as will appear from the following discussion of the effect of age of filters upon their bacterial efficiency.

The Effect upon Bacterial Efficiency of Period of Service (Age) of Filters.

In earlier reports it was noted that the effluents of water filters in some instances did not give normal bacterial results during the first days of operation. No definite period was fixed upon as necessary before normal results could be obtained, although in the report for 1893 it was stated that the bacteria in the effluents of new filters were so high during the first two weeks of operation that the results were not included in the averages.

A brief summary is instructive of the bacterial results obtained from the early operation of those filters which have been started since 1891, when river water, drawn from the canal, was introduced into the station.

The filters which were constructed in 1891 and 1892 contained fine or medium fine sand, with loam layers in several cases, and were operated in the beginning at rates not over 2,000,000 gallons per acre daily. Judging by the result from the application of typhoid fever and other germs, it appears that their removal by filters under these conditions was substantially normal during the very first days of operation. Some of the effluents contained low numbers of bacteria (less than 100 per cubic centimeter) from the outset, but in many cases the numbers were high. A discussion

of the ordinary water bacteria present in the effluents of this set of filters, when they were first started, has never been presented, because it is not clear to what degree the numbers were influenced by the food that was added with the applied germs. In parenthesis, it may be added that the systematic method in present use for the application of pure cultures of bacteria was not thoroughly developed until the latter part of 1892.

The filters which were constructed in 1893 contained coarser material than the earlier ones, but the initial rate of filtration exceeded 2,000,000 gallons per acre daily in only two instances. Viewed in the light of our present knowledge, the numbers of bacteria present in the effluents after starting were abnormally high for a period of weeks, varying considerably in the case of the different filters. Full accounts of these results were presented in the report of the Board for 1893, but for the sake of ready comparison they are summarized in a somewhat arbitrary way in the following table: —

Table showing Period of Operation of New (1893) Filters before They gave Indications of Attaining Normal Bacterial Efficiency.

Number of Filter.	Effective Size. — Millimeter	Depth of Material. — Inches.	Method of Operation.	Approximate Rate of Filtration. — Million Gallons per Acre Daily.	Number of Weeks which Filters had been in Operation when Effluents contained Numbers of Bacteria per Cubic Centimeter less than — 150.	100.	50.
3 B, ...	.23	60	Intermittent.	2	23	30	?
8 A, ...	.23	60	Continuous.	2	7	9	15
43, ...	.26	60	Continuous.	3	7	8	9
44, ...	.29	60	Continuous.	3	3	4	5
45, ...	.23	60	Intermittent.	2	5	5	19
46, ...	.29	12	Continuous.	2	2	3	4
47, ...	.29	60	Intermittent.	2	7	7	?
48, ...	.38	60	Intermittent.	2	7	7	?
49, ...	.38	60	Continuous.	2	3	5	11
Lawrence city filter, .	.26	60*	Intermittent.	1.2	5	26	?

* Minimum distance which water passes through sand.

By comparison of this summary with the results presented in the tables on pages 577 and 585, showing the bacterial efficiency in 1894 after the resumption of operations following the long period of rest in the case of the small filters (Nos. 43–49), as well as with the

results beyond from the larger filters, it is seen that these filters under the existing conditions did better work as they grew older.

From a study of the results of application of *B. prodigiosus* to these filters when they were new, it was found that the *bacterial purification*, as well as the *bacterial efficiency*, was abnormally low at that time, and that it also subsequently increased, according to later results.

With regard to the remaining filters studied in 1894, that is, those which were constructed before 1893, there has been a decided improvement in the average bacterial efficiency in each case, as is shown by the following table: —

Comparison of Average Bacterial Efficiency in 1893 and 1894.

Number of Filter.	Date when Constructed.	Average Rate of Filtration (Gallons per Acre Daily).		Average Bacterial Efficiency.	
		1893.	**1894.**	**1893.**	**1894.**
18 A, ...	Sept. 17, 1889,	1,880,000	4,870,000	96.75*	98.97
33 A, ...	April 28, 1892,	2,160,000	1,945,000	99.00	99.63
38, ...	April 28, 1892,	2,220,000	.2,900,000	99.02	99.82
41, ...	May 9, 1892,	1,840,000	2,005,000	99.57	99.82
42, ...	Oct. 29, 1892,	1,860,000	2,927,000	99.10	99.47

* Unusually low, owing to some very poor results obtained about October 1, when there was a change in the method of operating the filter intermittently, together with other abnormal conditions.

Sufficient evidence has already been presented to establish the point that the bacterial efficiency and the bacterial purification of water filters increase with age, other conditions being equal. The relation between age of filters and other factors, such as rate of filtration, depth of material, etc., with regard to their respective influence upon the results of filtration, will be discussed in turn under the proper headings. It is now proposed to examine the ways in which filters themselves change as they continue in service.

Gradual Changes in Filtering Materials. — Simply by inspection it is apparent that new sand is quite unlike that taken from filters which have been in operation for some time. The chief difference is that the grains of the latter are apparently covered with a sticky gelatinous coating, as will be demonstrated by Mr. Clark in a subsequent paper. In the case of grains situated at or just below the upper surface layer of sand this coating is so thick that the grains are considerably discolored. Here it is that the applied

bacteria are detained in the largest numbers. Passing downward into the main body of the sand a short distance, the discolorization disappears.

At this time further discussion of the composition of these gelatinous films is deferred, but there are numerous reasons for believing that they are an essential feature in the removal of bacteria from water by filtration, not only biologically, but also by virtue of their power of mechanical retention. Two of the most important reasons for this belief are as follows: —

1. In new filters, and in old filters which have been out of operation for a considerable period, normal bacterial results do not appear to be obtained until these films are formed.

2. In old filters which are in regular operation, and which yield normal chemical and bacterial results, a marked deterioration in these results occurs when for any reason there is a well-defined mechanical disturbance of the main body of sand, whereby the continuity of the films is broken to a certain degree.

So far as can be learned from the long series of experiments, those biological processes and conditions which cause the disappearance of bacteria may exist in filters to a normal degree, and yet the resulting effluent may show abnormally low bacterial purification, because the applied bacteria were not retained so that they could be killed. Bacteria do not appear to be killed in the few minutes or hours occupied by the water in its passage through the filter; and for that reason the mechanical aspect of filtration should not be forgotten, whatever may be its relative importance in comparison with the biological aspect.

Among the methods which may be mentioned for estimating the amount of coating upon the grains are frictional resistance to the passage of water and chemical analysis of the grains, as they are taken from the filter. Mr. Clark discusses the former in a subsequent portion of this volume, and we will illustrate at this time the latter method by the most marked case studied in 1894; that is, the results from Filters Nos. 18 A and 50.

This pair of filters contains 5 feet in depth in each case of coarse sand of the same effective size (0.48 millimeter). They were both put in operation July 23, 1894; Filter No. 50 was new on this date, while the other filter was constructed in 1889, but had been out of service since Dec. 8, 1893. The average rate of filtration was about 5,000,000 gallons per acre daily in each case; but it is to be noted

that Filter No. 18 A was operated intermittently and the other continuously. From our general knowledge of the subject and of the results from this pair of filters it does not appear that this last factor had much weight in this instance.

On July 23, 1894, the new sand in Filter No. 50 contained organic nitrogen to the amount of about 1 part per 100,000 by weight of dry sand. The average quantity in the sand of Filter No. 18 A was about three times as much on this date, as is shown by the tables and statements in the report of 1893, page 484.

When river water was applied to this pair of filters the result was that the new filter did not give normal bacterial efficiency until nearly three months after the beginning of operations, while No. 18 A, the old filter, showed normal efficiency in about ten days. Moreover, in October and November, when normal bacterial results were obtained from Filter No. 50, it was learned that this filter was at that time much more sensitive than Filter No. 18 A to disturbing influences, such as fluctuations in the rate of flow, as noted beyond.

On December 1 these filters were stopped for the winter. After allowing the water to drain from the sand, samples of the sand from different depths of each filter were collected for chemical and bacterial analyses, the results of which are as follows: —

Number of Bacteria and Amount of Organic Nitrogen found in Different Depths of the Sand of Filters Nos. 18 A and 50, Dec. 1, 1894.

Depth from Surface (Inches).	Organic Nitrogen* (Parts per 100,000 by Weight of Dry Sand).		Bacteria per Gram.	
	Filter No. 18A.	Filter No. 50.	Filter No. 18A	Filter No. 50.
0-¼,	12.6	26.2	2,760,000	7,560,000
1,	15.1	13.3	2,100,000	1,000,000
3,	14.3	8.5	700,000	51,100
6,	9.0	4.8	588,000	80,500
12,	6.4	3.8	26,000	91,000
24,	3.1	2.6	44,100	35,000
36,	2.1	2.0	17,000	64,000
48,	1.5	1.6	17,000	24,000
60,	2.0	1.0	36,000	42,000

* The organic nitrogen was calculated as $\frac{14}{17}$ of the albuminoid ammonia doubled; and no deduction was made of the nitrogen originally present in the sand.

The smaller amount of nitrogen and fewer bacteria at the surface of Filter No. 18 A are explained by the fact that the surface had been scraped more recently than was the case with Filter No. 50. From depths of 3 to nearly 24 inches below the surface the organic nitrogen in the sand of Filter No. 50 was only about 60 per cent. of that in Filter No. 18 A. In the case of the latter filter it will be noted that high numbers of bacteria were found in the sand at greater depths from the surface than in the case of the former filter, and there are strong grounds for believing that the greater amount of organic matter attached to the sand grains for some distance below the surface of Filter No. 18 A was a prominent factor in explanation of its resistance to the disturbing influences, which caused a diminution in the bacterial efficiency of Filter No. 50.

On July 23 the new sand of Filter No. 50 contained practically no organic matter arranged as such films around the grains as was later the case with the sand of the upper portion of the filter. Filter No. 18 A at that time did possess sufficient organic matter to quickly form gelatinous films around its grains; and it is instructive to compare its bacterial efficiency with that of Filter No. 50 during the period when the accumulated organic matter gradually formed in the latter filter those sticky coatings upon which, apparently, normal bacterial efficiency is dependent to a certain degree in filters of coarse material.

Average Weekly Results of the Daily Determinations of the Number of Bacteria in Applied River Water and in Effluents of Filters Nos. 18 A and 50.

[July 23-Oct. 27, 1894.]

Week ending —	Bacteria per Cubic Centimeter.			Week ending —	Bacteria per Cubic Centimeter.		
	Applied River Water.	Effluents of Filters Nos. —			Applied River Water.	Effluents of Filters Nos. —	
		18 A.	50.			18 A.	50.
1894.				1894.			
July 28, . .	3,100	2,840	5,300	Sept. 15, . .	12,200	162	272
Aug. 4, . .	2,800	52	3,500	22, . .	16,700	91	307
11, . .	4,000	77	1,739	29, . .	49,700	224	218
18, . .	2,600	84	375	Oct. 6, . .	65,800	390	364
25, . .	4,700	120	380	13, . .	53,800	810	630
Sept. 1, . .	3,000	91	856	20, . .	4,900	168	230
8, . .	4,000	60	290	27, . .	4,100	61	77

With filters of finer material the differences in the bacterial contents of the effluents, as shown in the last table, would be less marked. Nevertheless, the records already presented prove that the bacterial efficiency of filters of fine sand increases with age. At this point, while we are considering the relation between bacterial efficiency and the organic matter in the sand arranged as gelatinous films around the grains, it is of importance to observe that in practically every case there has been an increase during 1894 of organic matter stored in the sand of the filters.

This fact is established by a comparison of the results of chemical and bacterial analyses of numerous samples of sand collected from various depths of the several filters in December, 1894, with the results of corresponding analyses made at the close of the preceding year. The 1893 results were presented in the annual report for that year, page 485, arranged in the form of averages for different sections of the filters. Owing to the fact that new sand had been added to many of the filters, causing old surfaces to appear at various depths from the present surface, the results are somewhat irregular, especially so in the case of the 1893 set. For this and other reasons the averages are not presented at this time, but instead the results of individual analyses are given.

The organic nitrogen is calculated as fourteen-seventeenths of the albuminoid ammonia doubled, and in no case is any deduction made for the nitrogen originally present in the sand.

Comparison of the Amount of Organic Nitrogen and Number of Bacteria found in Different Depths of Sand from the Several Filters, Dec. 8, 1893, and Dec. 1, 1894.

Filter No. 18 A.

Depth from Surface (Inches).	Organic Nitrogen (Parts per 100,000 by Weight of Dry Sand).		Bacteria per Gram.	
	Dec. 8, 1893.	Dec. 1, 1894.	Dec. 8, 1893.	Dec. 1, 1894.
0-¼,	18.4	12.6	1,570,000	2,760,000
1,	5.0	15.1	840,000	2,100,000
3,	3.4	14.3	140,000	700,000
6,	7.4	9.0	120,000	588,000
12,	9.4	6.4	111,000	26,000
24,	2.8	3.1	36,000	44,000
36,	2.0	2.1	18,500	17,000
48,	1.6	1.5	6,800	17,000
60,	4.7	2.1	44,700	36,000

Filter No. 33 A.

Depth from Surface (Inches).	Organic Nitrogen (Parts per 100,000 by Weight of Dry Sand).		Bacteria per Gram.	
	Dec. 8, 1893.	Dec. 1, 1894.	Dec. 8, 1893.	Dec. 1, 1894.
0-¼,*	6.1	19.3	767,000	6,370,000
1,	6.6	5.1	228,000	1,500,000
3,	2.6	3.3	40,000	800,000
6,	0.8	1.6	75,700	70,000
12,	9.4	4.1	30,000	30,000
24,	2.2	2.6	8,000	18,000
36,	1.8	2.1	15,000	7,000
48,†	1.5	1.6	8,000	6,000

Filter No. 38.

Depth from Surface (Inches).	Organic Nitrogen, Dec. 8, 1893.	Organic Nitrogen, Dec. 1, 1894.	Bacteria, Dec. 8, 1893.	Bacteria, Dec. 1, 1894.
0-¼,	12.3	23.2	3,430,000	8,400,000
1,	6.9	9.5	1,670,000	4,200,000
3,	8.4	4.6	10,700	190,000
6,	4.1	3.3	9,600	27,000
12,	3.3	5.4	5,600	21,600
24,	3.1	2.6	11,000(?)	7,100

Filter No. 41.

Depth from Surface (Inches).	Organic Nitrogen, Dec. 8, 1893.	Organic Nitrogen, Dec. 1, 1894.	Bacteria, Dec. 8, 1893.	Bacteria, Dec. 1, 1894.
0-¼,	1.9	20.0	1,750,000	7,420,000
1,	3.2	5.6	108,000	1,470,000
3,	1.5	2.9	45,000	620,000
6,	0.9	2.8	80,000	77,000
12,	9.5	5.7	24,000	38,000
24,	2.0	3.6	21,000	28,000
36,	2.1	2.1	6,000	23,000
48,	2.0	1.9	1,500	17,000

Filter No. 42.

Depth from Surface (Inches).	Organic Nitrogen, Dec. 8, 1893.	Organic Nitrogen, Dec. 1, 1894.	Bacteria, Dec. 8, 1893.	Bacteria, Dec. 1, 1894.
0-¼,	9.8	18.3	1,750,000	4,200,000
1,	6.9	8.2	111,000	4,600,000
3,	5.7	5.4	54,000	1,200,000
6,	3.6	4.4	32,100	84,000
12,	4.1	5.2	4,200	64,000

* The value to be attached to comparisons of results of analyses of sand from the upper quarter of an inch is quite limited, as the results are closely related to a variable period beginning with the last scraping.

† In several of the five-foot filters it was impracticable to collect satisfactory samples from the lowest foot.

Filter No. 43.

Depth from Surface (Inches).	Organic Nitrogen (Parts per 100,000 per Weight of Dry Sand).		Bacteria per Gram.	
	Dec. 8, 1893.	Dec. 1, 1894.	Dec. 8, 1893.	Dec. 1, 1894.
0-¼,	?	21.8	9,300,000	5,460,000
1,	1.3	13.3	67,200	1,500,000
3,	3.6	6.9	183,000	820,000
6,	6.2	4.1	188,000	245,000
12,	1.7	4.1	105,000	120,000
24,	0.7	1.8	6,500	49,000
36,	0.5	1.0	14,200	42,000
48,	0.5	0.6	22,000	35,000
60,	0.8	1.3	22,500	13,500

Filter No. 44.

0-¼,	1.5	23.9	2,020,000	8,400,000
1,	11.1	10.3	2,050,000	1,740,000
3,	5.9	7.4	1,200,000	600,000
6,	3.4	9.2	51,000	126,000
12,	2.4	6.4	50,000	70,000
24,	0.7	3.1	?	48,000
36,	0.7	2.5	130,000	34,000
48,	0.8	1.8	8,200	28,000
60,	0.7	2.0	16,100	21,000

Filter No. 45.

0-¼,	5.9	25.9	1,850,000	7,480,000
1,	1.0	12.8	100,000	1,290,000
3,	1.5	7.9	?	539,000
6,	4.6	5.6	?	165,000
12,	2.5	3.1	47,000	84,000
24,	2.0	1.8	65,400	40,000
36,	0.6	1.3	25,500	25,000
48,	0.6	1.1	19,000	27,000
60,	0.5	1.3	14,000	28,000

Filter No. 46.

Depth from Surface (Inches).	Organic Nitrogen (Parts per 100,000 by Weight of Dry Sand).		Bacteria per Gram.	
	Dec. 8, 1893.	Dec. 1, 1894.	Dec. 8, 1893	Dec. 1, 1894.
0-¼,	3.8	16.6	1,900,000	9,800,000
1,	1.6	4.1	675,000	600,000
3,	1.2	4.8	116,000	130,000
6,	4.6	2.8	13,000	24,000
12,	3.3	4.9	7,000	14,000

Filter No. 47.

0-¼,	9.2	15.6	3,500,000	7,700,000
1,	5.8	7.5	170,000	2,040,000
3,	6.2	5.9	93,600	1,010,000
6,	3.1	4.7	105,000	720,000
12,	1.5	2.9	79,000	245,000
24,	0.8	2.0	32,600	105,000
36,	0.7	1.6	67,000	64,000
48,	0.5	1.3	30,600	84,000
60,	0.6	1.1	63,000	35,000

Filter No. 48.

0-¼,	4.9	14.4	1,700,000	5,600,000
1,	3.8	2.6	470,000	1,850,000
3,	2.2	2.0	?	540,000
6,	1.3	1.2	57,000	245,000
12,	1.0	0.9	28,000	105,000
24,	0.6	0.7	18,000	50,000
36,	0.4	0.5	18,000	42,000
48,	0.7	0.5	22,000	3,400

Filter No. 49.

0-¼,	1.1	19.9	830,000	7,140,000
1,	2.7	9.8	126,600	4,900,000
3,	7.0	5.1	?	1,500,000
6,	6.5	3.9	120,000	655,000
12,	1.4	2.5	25,000	94,000
24,	0.8	1.5	38,000	49,000
36,	0.5	1.1	31,000	28,000
48,	?	0.8	?	16,000

Attention is called to the discussion by Mr. Clark upon the increasing compactness of filters, as they continue in service. This is a matter of much practical importance in this connection, and is caused in part by the pressure upon the sand of the body of water which it supports.

The Effect upon Bacterial Efficiency of Rate of Filtration of Water.

Under this heading we shall first consider the effect of differences in rates of filtration, where the rates are kept approximately constant.

From the 1892 results, obtained for the most part from filters six to eight months old, and constructed of fine or medium fine sand, it was concluded that more bacteria were able to pass the filters at high rates (not over 3,000,000 gallons) than at low rates (500,000 gallons). It was also noted at that time that the effect of rates, in those experiments, was slight, and limited to a variation of a fractional part of one per cent. of the applied bacteria.

In 1893 the results were obtained from one filter which had been in operation four years, nine filters which had been operated twelve to eighteen months and nine more in which the period was three to six months. With this set of experiments the influence of the rate of filtration upon the bacterial results could not be clearly traced in several instances; in fact, in some cases its influence was completely disguised by other factors. The conclusion drawn at that time was that low rates are undoubtedly safer than high rates; but, nevertheless, up to a certain limit the rate apparently exerts very little influence, and this limit is different for different filters and varies with other conditions in the case of the same filter.

In 1894 the experiments have been continued with the addition of two new filters to a majority of those which were studied during the preceding year. Ten of these filters have been operated at rates of 5,000,000 gallons or more per acre daily, and from *those filters which had been in operation for a considerable period* the average bacterial results have been satisfactory. With the remaining filters, operated at rates of less than 5,000,000 gallons per acre daily, the bacterial results have been more satisfactory than at corresponding rates during previous years.

Influence of Length of Period of Operation (Age) of Filters.

The evidence accumulated during each successive year of investigation at Lawrence has apparently shown the effect of rate of filtration of water upon bacterial efficiency of filters to be less and less. From this it follows that the more recent results have been obtained from experiments in which there were present one or more conditions that disguised to a large degree the effect of rate of filtration. The 1893 results were such as to lead to this belief, and the results of the past year have proven the soundness of the view.

With our present knowledge it may be stated that the factor which causes the effect of the rate of filtration upon bacterial efficiency to become practically *nil*, under normal conditions, is chiefly the age of the filter. The reason of this lies probably in the increased accumulation of organic matter arranged around the sand grains as gelatinous films, whereby more favorable conditions are offered for the mechanical retention of the bacteria under a biological environment which causes them to disappear. This explanation, in the light of the evidence in the earlier portion of this report (page 595), will make it clear that age of filters refers to period of actual operation, and does not include periods of rest.

This view seems to hold true under the conditions studied at Lawrence for rates of filtration several times as great as that generally recognized as the limit, as is pointed out below. It will be noted that the above conclusion is limited to normal conditions; by this is meant carefully controlled conditions, such as should obtain in actual practice. With these high rates it has been found that under unusually severe conditions, such as scraping to a depth of more than one inch, the bacterial efficiency was less than at lower rates of filtration.

Limits in Rate of Filtration which may be safely adopted in Practice.

Experience during the past two years, with ten different filters which have been in operation at rates of 5,000,000 gallons or more per acre daily, leads us to the conclusion that with conditions substantially equivalent to those at Lawrence the above-mentioned rate may be safely adopted in practice, and yield an effluent of satisfactory quality after the first or second month of operation. The results upon which the above conclusion is based have been obtained

from five-foot filters, two of which are 17 feet in diameter, and placed out of doors without protection from the weather.

During the first few weeks of operation of a filter the effect of rate of filtration seems to be more marked than subsequently; but even under these circumstances its importance has been found to be reduced considerably in some instances by other factors, such as chemical composition of sand, for example.

A summary by months of the 1894 results from filters operated at high rates when filtering river water drawn from the canal is presented in the table below. These averages include all results, some of which were obtained under conditions which can and should be avoided in practice. Particularly was this the case in October and November, when, at times of very high numbers of bacteria in the applied river water, the surfaces were scraped to a depth of an inch or more, and when the rates of filtration were subjected to marked fluctuations. To obtain a fair idea of the normal work of the filters it is necessary to study the results of individual analyses, presented beyond. In the consideration of the limit in rate, mentioned above, attention is called to the satisfactory results obtained, under normal conditions, from Filter No. 44, at 7,500,000 gallons, and from Filter No. 49, at 10,000,000 gallons, per acre daily.

Monthly Averages of the Number of Bacteria per Cubic Centimeter in Merrimack River Water Before and After Filtration.

	Approximate Rate of Filtration. — Million Gallons per Acre Daily.	1894.				
		Aug.	Sept.	Oct.	Nov.	Dec.
River (canal) water,	–	3,500	20,000	29,000	10,800	21,000
Effluent, Filter No. 3 B,	5	61	37	61	194	237
" " 8 A,	5	22	19	35	147	271
" " 18 A,	5	86	136	330	101	–
" " 43,	5	50	108	438	141	–
" " 44,	7.5	40	76	275	51	–
" " 45,	5	18	59	165	103	–
" " 47,	7.5	45	118	401	205	–
" " 48,	5	–	–	–	262	–
" " 49,	10	–	–	–	180	–
" " 50,*	5	922	283	258	100	–

* New filter.

The above data, together with the foregoing explanation, indicate that satisfactory *bacterial efficiency* has been obtained so far as the rates of filtration are concerned. A fairer idea of the *hygienic efficiency* may be obtained from the results of *bacterial purification* by the filters; or, to avoid technical expressions, the results of the application to the filters of *B. prodigiosus*, a germ which does not seem to grow within the filters and which appears to behave very similarly in water to the germ generally recognized as the cause of typhoid fever.

B. prodigiosus was applied to each filter, except Nos. 3 B and 8 A, during October and November, for ten hours per day, according to the plan described in earlier reports. The average results of this application are as follows: —

Monthly Averages of the Numbers of B. Prodigiosus per Cubic Centimeter applied in River Water to Water Filters, and found in Their Effluents, 1894.

Month.	Applied in River Water.	In Effluents of Filters Nos. —							
		18 A.	43.	44.	45.	47.	48.	49.	50.
October, . . .	3,900	3	6	4	1	2	-	-	2
November, . . .	4,800	1	3	1	2	2	5	2	3

These results show that on an average about 1 in 1,700 of the applied germs was found in the effluents; that is, there was a bacterial purification of 99.93 per cent. As has been already noted in the case of the water bacteria, the presence in the effluent of many of the *B. prodigiosus* germs was caused by abnormal conditions which do not of necessity belong to the process of water filtration. The significance of these circumstances is that while under normal conditions these applied germs were practically all retained in the filter until they perished, yet these disturbances were so marked as to cause relatively large numbers of them to pass into the effluent; or, in other words, the above averages are made up to a large extent of relatively high numbers obtained in a few days during the period.

Detailed study of the 1,070 individual results, upon which the averages in the last table are based, shows that in 52 per cent. of them no *B. prodigiosus* was found. Furthermore, it was learned that on an average the above-mentioned bacterium was not found in the effluents on 42 per cent. of the days when it was applied to the filters.

During the early part of December the effluent of Filter No. 8 A contained unusually high numbers of bacteria, apparently owing to the repeated disturbances of the surface in November. To obtain more precise knowledge of its efficiency, *B. prodigiosus* was applied for ten hours a day, December 5–15, in numbers averaging about 300 per cubic centimeter of river water. Repeated bacterial analyses of the effluent were made during this period and on subsequent days, but the germ in question was not found in any instance. By means of a modification (described in the paper on methods, beyond) of the ordinary methods of analysis 50 cubic centimeters were examined at a time on several occasions, with negative results in each case, so far as the presence of *B. prodigiosus* was concerned.

In passing, it may be noted that the results of the application of these smaller numbers of bacteria in pure culture doubtless give a fairer idea of the true hygienic efficiency of filtration than the larger numbers formerly used. The reason of this lies in the fact that there is less opportunity for accumulation in large numbers of these germs within the filter, thereby furnishing, apparently, certain conditions which conduce to longevity, and also to their passage into the effluent when disturbing influences are present. During the earlier years of the investigations the application of comparatively large numbers of bacteria in pure cultures was an absolute necessity, in order to obtain in the effluent numbers so great that they could be relied on for the formulation of the laws of filtration.

From the application of *B. prodigiosus* to Filter No. 8 A (17 feet in diameter and containing 5 feet in depth of medium fine sand) in December, it is concluded that with this filter, running under normal conditions and filtering Merrimack River water at the rate of 5,000,000 gallons per acre daily, less than 1 in 15,000 of *B. prodigiosus*, when applied in relatively small numbers, passed through the filter into the effluent; that is, there was a bacterial purification of more than 99.993 per cent.

Evidence of Limitations to the Theory that "Qualitative Efficiency of Water Filters is Inversely Proportional to Their Quantitative Efficiency."

From the experimental investigations upon sand filtration made by Frænkel and Piefke in 1889 at Berlin it was thought that the results with regard to the rate of filtration warranted the statement quoted above. The question arises, however: Were such experi-

mental filters operated long enough to establish thoroughly the truth of the theory? Lawrence experiments and results would indicate that they were not. Some of their experimental filters were built of fresh sand, but most of them were constructed with material taken at different depths from filters which had been in actual service for years, and all of them were operated for a comparatively short time.

From the experience obtained at Lawrence, where the investigations have been made upon water filters which have been continued in service for several years, it is clear that the above-mentioned theory, while probably true for new filters under some conditions, is not true for filters which have been in service for a long period. In proof of this we may say that while some results obtained during a short period in 1892 from filters which had been in operation less than six months pointed, in a general way, towards a confirmation of the theory in question, confirmatory results could not be obtained when the filters were older, owing apparently to a more extended accumulation of gelatinous films within the main body of the filtering material.

Before closing the discussion upon this point it is proper to call attention to the fact that sanitarians are chiefly interested in the real and permanent efficiency of a filter rather than its efficiency during the first weeks of operation. These first weeks, when normal bacterial results in many cases are not forthcoming, may be regarded as a necessary period of "biological or chemical construction" as truly as the more obvious case of a necessary period of engineering construction.

The Effect upon Bacterial Efficiency of Changes in the Rate of Filtration.

From our experience with water filters, under the conditions described in this and preceding reports, the general statement may be made that decreases in the rate of filtration, other conditions being equal, have been followed by a very moderate decrease in the number of bacteria in the effluent, if any change in the bacterial results was noticeable. A discussion of the present problem, therefore, becomes a consideration of the effect of increments of the rate of filtration.

For the sake of clearness in the presentation of the results of the experiments along this line the increased rates will be divided into two classes:—

1. Those increments in the rate of filtration where the increase has for its initial point the rate at which the filter is normally operated.

2. Those increments in the rate of filtration (following a decrease) where the increased rate does not exceed the normal.

Considerable evidence upon the first problem was accumulated during 1893, and a discussion of this portion of the subject will be presented first.

Increases in Rate above the Normal. — During 1893 there were numerous instances where the rate of filtration of the filters was increased above that which was normal at the time of change, and in a majority of cases this treatment was followed by an increase in the number of bacteria in the effluent, as was noted in the annual report for that year. In 1894 the prescribed rates of filtration, as a general rule, for those filters which have received river water from the canal have been regularly maintained as accurately as possible, and no permanent increases in the rates have been made except in the case of Filters Nos. 3 B and 8 A. The rates of filtration, however, of a majority of the small twenty-inch filters have been temporarily increased, with results which are given after the following account of Filters Nos. 3 B and 8 A.

On July 20, 1894, when Filters Nos. 3 B and 8 A had been in constant service for about ten months, the rate of filtration in each case was increased from 2,000,000 to 5,000,000 gallons per acre daily. This treatment caused a marked increase in the number of bacteria in both effluents for several days, as is shown by the following table : —

Average Daily Results of the Determination of the Number of Bacteria per Cubic Centimeter in Effluents of Filters Nos. 3 B and 8 A, arranged to show the Effect of Increase in Rate of Filtration.

Date.	Applied River Water.	Effluent of Filters Nos. —		Date.	Applied River Water.	Effluent of Filters Nos. —	
		3 B.	8 A.			3 B.	8 A.
1894.				1894.			
July 16, . .	1,800	52	8	July 22, . .	-	-	-
17, . .	2,500	44	15	23, . .	1,300	543	978
18, . .	7,500	52	9	24, . .	3,400	378	1,800
19, . .	8,900	42	12	25, . .	3,300	80	192
20, . .	7,900	63	53	26, . .	3,700	114	158
21, . .	3,800	732	1,281	27, . .	4,500	61	27

Concerning the above results there are two features which are worthy of note. The samples of effluents represented by the results of July 20 were collected after the increase was made in the rate of filtration, but before the effluent pipe contained water which had passed through the *upper portion of the filter* at the increased rate. Instances of a somewhat similar nature have been repeatedly observed, all of which go to show that it is the upper portion of a filter upon which its efficiency in the removal of bacteria chiefly depends.

Filter No. 8 A was scraped on July 24, and was put in operation directly after filling with river water from the top. Unusually high numbers of bacteria in the effluent followed this treatment. These results are chiefly instructive as an unusual illustration of diminished bacterial efficiency, owing to abnormal conditions, but which may be avoided by proper management, as will be observed from the discussion beyond.

In the next table is presented a summary of the results obtained from increasing temporarily (usually about six hours) the rate of filtration of a majority of the in-door experimental filters. Without going into details concerning the several filters, the history and conditions of which are presented beyond, in the account of the work of the filters for the year 1894, the general statement may be made that these results represent a wide range in the conditions of construction and operation of filters and in length of service.

One of the most prominent features of the next table is the fact that an increase from 2,200,000 to 5,000,000 gallons per acre daily in the rate of filtration of Filter No. 8 A on May 14 was followed by a very slight change in the bacterial results, when compared with those results obtained from a corresponding increase in the rate of this filter on July 21, as has just been described. It is to be said, however, that on May 14 the rate was increased late in the afternoon, and no bacterial samples of the effluent were collected until the next morning. A question mark is placed after these results, because it is possible that an increase in the number of bacteria in the effluent occurred before the collection of samples was begun. Nevertheless, the fact remains that, if there was an increase in the number of bacteria in the effluent during the night of May 14, the effect of the increased rate was very much less marked than was the case on the later date.

The reason of the discrepancy in the results obtained from apparently similar experiments upon Filter No. 8 A in May and July is not

fully understood. It was thought at first that there might have been some unknown disturbance of the surface layer on July 21; but careful examination of the notes and the confirmatory experience with Filter No. 3 B caused this idea to be dismissed.

The above remarks upon the variations in the length of period during which the increase in the rate of filtration influenced the bacterial contents of the effluents lead to the statement that in the following table the maximum numbers of bacteria after a change in rate correspond to only a comparatively small quantity of effluent. In some instances the increased numbers of bacteria were found in the effluent for short periods of less than one hour. This period may be defined approximately as the time when the water, which was held in the pores of the upper portion of the filter at the time of increase in the rate, reached the effluent pipe. This fact suggests, as one of the causes of the increased numbers of bacteria in the effluent, a detachment of bacteria from those sand grains around which they are grouped in the largest numbers. Normal bacterial results were obtained in all cases (except Filters Nos. 3 B and 8 A on July 21) within a few hours after the change was made; the longest period of disturbance was about twelve hours.

Summary of Bacterial Results, to show the Effect of increasing the Rate of Filtration above the Normal.

Number of Filter.	Date.	Change in Rate. Million Gallons per Acre Daily.	Multiple which increased Rate is of that before Change was made.	Number of Bacteria per Cubic Centimeter in Effluents. Before Change.	After Change (Maximum).	Multiple which Latter Number of Bacteria is of Former.
	1894.					
3 B, ...	July 21,	2-5	2.5	63	732	11.6
8 A, ...	May 14,	2.2-5	2.3	25	41(?)	1.6(?)
8 A, ...	July 21,	2-5	2.5	53	1,281	24.2
33 A, ...	Nov. 7,	2-7.5	3.7	8	210	26.0
33 A, ...	10,	2-5	2.5	40	270	6.7
38, ...	5,	3-5.5	1.8	150	380	2.5
38, ...	9,	3-4.5	1.5	93	210	2.2
38, ...	28,	3-5	1.7	32	103	3.2
43, ...	9,	5-7	1.4	135	350	2.6
43, ...	28,	5.5-8	1.5	130	375	2.9
44, ...	12,	7-10	1.4	111	230	2.1
46, ...	5,	2.5-5.5	2.2	180	275	1.5
48, ...	10,	5-6.5	1.3	450	700	1.6
48, ...	27,	4-7.5	1.9	289	546	1.9
49, ...	27,	10-15	1.5	60	113	1.9
50, ...	2,	5.5-10	1.8	60	97	1.6
50, ...	7,	5.5-11	2.0	595	1,120	1.9
50, ...	27,	5-8	1.6	27	185	7.0
50, ...	28,	5-8.5	1.7	40	130	3.2

It was also found that increases in the rate of filtration of 50 per cent. above the normal usually cause increases in the number of

bacteria in the effluent, for a short time, of two to seven fold. The bacterial results are variable, and in some instances the increase in numbers has been less than is indicated to be the case by the general statement made above. It is not fully understood what are the factors, and their significance, which are to be considered in the explanation of these observations. At present, however, the two most important seem to be coarseness of sand and length of period during which the filters have been in service.

The results from Filters Nos. 3 B, 8 A and 33 A indicate that, with increases in the rate of more than 50 per cent. above the normal, there is more likelihood of a greater increase in the bacterial contents of the effluent. It will also be noted that increases in the rate of 30 and 40 per cent., respectively, caused well-marked increases in the numbers of bacteria in the effluents.

With regard to the effect of smaller increases in the rate (10 or 20 per cent.), the evidence at hand is not sufficiently complete to warrant a final conclusion. It is probable, however, that the bacterial results would be affected for a short time by such an increase in the case of comparatively new filters of coarse material. But with filters under normal conditions increased numbers of bacteria in the effluents have not been found after such increases in the rate. It may be stated here that each result presented in the last table is based upon from ten to fifteen bacterial analyses. If a greater number of analyses of the effluents had been made after these small increases in the rate took place, it is possible that increased numbers of bacteria would have been found; but it is clear that, if such bacterial results did arise, the increases in numbers must have been very moderate and of very short duration.

Increases in Rate below the Normal. — In the consideration of the effect upon bacterial efficiency of increases in rate of filtration below the normal (following a decrease), the first point that suggests itself is the increasing rate in an intermittent filter to which water has just been applied after it has been allowed to drain. It is true that higher numbers of bacteria have been repeatedly found in the effluent of some intermittent filters during the portion of the flow which has just been described. A careful study of this subject, however, has led to the conclusion that such bacterial results are not caused by the changes in rate, but arise from mechanical disturbances in the upper portion of the main body of the material; and under some circumstances these disturbances appear at the same time as the change in

rate. This conclusion is based upon the results of numerous experiments which have yielded normal bacterial results under this changing rate, but in the absence of the disturbing influence noted above.

The effect upon the bacterial efficiency of continuous filters of stopping them and then putting them in operation again at the normal rate of filtration, has been investigated in the case of several filters with different conditions of construction and operation. In some instances the operation of the filters was stopped for thirty to forty hours, owing to the water having been shut off on account of repairs, etc.; and in other cases the length of period during which the filters were out of action was only a few minutes.

Information concerning the bacterial results which follow the longer period of rest has been obtained from about thirty sets of experiments. With Filter No. 8 A, when operated at a rate of 2,000,000 gallons per acre daily, there were no appreciable bacterial increases in the effluent during May and June, upon starting the filter after a period of rest. During the rest of the year, higher numbers of bacteria in the effluent of this filter, operated at a 5,000,000 gallon rate, were occasionally, but not regularly, found under these circumstances. When such bacterial results were noted, the increases were always moderate, as, for example, from 14 to 40 per cubic centimeter, on August 6, and from 43 to 110 per cubic centimeter on September 10. With filters of fine material, such as No. 33 A, no increase in the number of bacteria under these conditions has ever been observed. With the small filters of coarser materials, the effluents on August 6, about two weeks after the filters had been put in operation for the year, and when they resembled new filters, showed marked increases in their bacterial contents when they were started after a rest of sixty hours. Actual changes in the number of bacteria per cubic centimeter in the effluents were as follows: from 12 to 238, Filter No. 43; from 10 to 150, Filter No. 44; and from 700 to 4,600, Filter No. 50 (new). It is instructive to note that on November 5, when the filters had in all cases been in regular service for at least three and one-half months, there were no such increases, as noted above, in the bacterial contents of any of the effluents when the filters were put in operation, after a rest of thirty-six hours. The size of sand grains, rate of filtration, etc., had far less influence than in August. There was an increase, however, in some cases in the number of bacteria in the effluents, equal on an average of from 22 to 46 per cubic centimeter.

In the table beyond there are recorded some interesting results obtained from the various filters, with regard to the effect upon bacterial efficiency of lowering the rate of filtration for one to three hours and then quickly restoring it to the normal. As is the case with the table on page 613, the numbers of bacteria per cubic centimeter in the effluents, before the changes were made, are given, together with the *maximum* number found after the change. It may be further stated here that each set of results in the next table represents from ten to twenty bacterial analyses of the effluent, a majority of which were made of samples collected at about the time when the water which was in the upper portion of the filter when the rate was restored to the normal passed through the outlet pipe.

From these results, obtained under the given conditions, it is clear that practically no effect upon the bacterial efficiency was produced by the given changes in rate of filtration, except in the case of the comparatively new Filter No. 50 of coarse material. With this filter, furthermore, when the rate of filtration was fluctuated from 1,000,000 to 5,000,000 gallons per acre daily, the abnormal bacterial results were obtained for only about an hour, at the time specified in the above paragraph.

Summary of Bacterial Results to show the Effect of increasing, after decreasing the Rate of Filtration below the Normal.

Number of Filter.	Date.	Changes in Rate. Million Gallons per Acre Daily.	Number of Bacteria per Cubic Centimeter in Effluents.	
			Before Change.	After Change (Maximum).
	1894.			
8 A,	Aug. 11,	5-1-5	7	35
8 A,	Oct. 19,	5-1-5	2	12
8 A,	Nov. 2,	5-0.7-5	11	14
38,	Oct. 23,	3-1-3	8	4
42,	" 23,	3-1-3	14	16
42,	" 26,	3-2.5-3	49	43
43,	" 17,	5-1-5	245	280
43,	" 31,	5-3.5-5	52	51
44,	" 17,	7.5-1-7.5	130	175
44,	" 24,	7-1-7	43	34
44,	" 31,	7.5-6-7.5	20	50
46,	" 12,	2.5-0.7-2.5	221	184
46,	" 24,	2.5-1-2.5	8	12
48,	" 12,	2.5-1-2.5	4	8
48,	" 26,	5-1-5	231	81
48,	" 29,	5-4-5	139	117
49,	" 12,	5-1-5	4	5
49,	" 29,	10-5-10	150	175
50,	" 6,	5-1-5	588	2,974
50,	" 11,	5-1-5	1,113	2,800
50,	" 19,	5-4-5	117	118
50,	" 26,	5-4-5	96	102

Owing to the temporary nature of the increase in the number of bacteria in the effluent of Filter No. 50 on October 6, it is worth while to present the individual results of that experiment. The rate of filtration was lowered from 5,000,000 to 1,000,000 gallons per acre daily from 9.15 A.M. to 12.10 P.M. The applied river water contained on an average 69,000 bacteria per cubic centimeter; in addition to these ordinary water bacteria, *B. prodigiosus* was added in the proportion of 3,800 per cubic centimeter of applied water, when the filter was operated at the higher rate. At the lower rate the number of applied *B. prodigiosus* was five times as great.

From the results of analyses presented in the next table, it is seen that the sample collected at 3 P.M. was the only one which showed abnormal bacterial contents of the effluent. In the consideration of the *B. prodigiosus* results in the samples collected at 4, 5 and 6 P.M., respectively, it is to be mentioned that they correspond to the portion of applied water which received five times the usual dose of these germs. For this reason, then, these results are fairly normal.

Number of Bacteria per Cubic Centimeter in the Effluent of Filter No. 50, at Different Rates of Filtration, Oct. 6, 1894.

Hour.	Rate of Filtration. Million Gallons per Acre Daily.	Bacteria per Cubic Centimeter. Water Bacteria.	*B. Prodigiosus.*	Hour.	Rate of Filtration. Million Gallons per Acre Daily.	Bacteria per Cubic Centimeter. Water Bacteria.	*B. Prodigiosus.*
8.00 A.M., . .	5	588	2	1.00 P.M., . .	5	324	4
8.45 " . .	5	567	1	2.00 " . .	5	354	3
9.10 " . .	5	532	3	3.00 " . .	5	2,974	46
10.00 " . .	1	420	1	4.00 " . .	5	500	10
11.00 " . .	1	376	1	5.00 " . .	5	535	8
12.00 M., . . .	1	397	0	6.00 " . .	5	490	8
12.30 P.M., . .	5	560	1				

This experiment was one of the first of its kind to be made, and subsequently more samples were collected in each case, at times corresponding to the period between 2 and 4 P.M. in the above table. Samples were collected at intervals of fifteen minutes on October 11, when this experiment upon Filter No. 50 was repeated.

The results of bacterial analyses of the second set of samples showed that with the given conditions abnormal bacterial efficiency

was obtained for about one hour. From the "prodigiosus" results it appears that the bacterial purification was somewhat similarly affected. The prodigiosus results are not tabulated, because complications were unintentionally introduced with regard to the uniform application of this germ in a definite proportion. Nevertheless, the results from the application of this germ have been of value in a general way in throwing light upon the problem in question.

General Conclusions as to the Relation between Hygienic Efficiency and Rate of Filtration.

It is plain, in the light of the evidence presented in the foregoing pages, that the rate of filtration under the conditions at Lawrence is a less prominent factor in the removal of bacteria by filters which have been regularly in operation for some time than was formerly supposed to be the case. Among the reasons for this it may be mentioned that a majority of experimental investigations upon this point have been made with filters which have been in service only for a comparatively short time.

From a practical point of view it is desired at this time to call attention to two important points, as follows: —

1. With properly constructed filters which are carefully operated at a uniform moderate rate of filtration (not over 5,000,000 gallons per acre daily) and with the Merrimack River water satisfactory hygienic results may be regularly obtained.

2. But with filters which are so constructed and so operated that a portion of the filtering area yields an effluent at a rate several times in excess of the average rate, and with a corresponding portion of the area filtering at a rate much lower than the average, it is improbable that filters under such circumstances can be uniformly relied upon to furnish satisfactory hygienic results.

Economy of High Rates of Filtration.

The question of the cost of a plant for the filtration of a public water supply involves two principal items, as follows: the cost of construction, including provisions for the interest on the capital invested and for sinking funds, and the cost of actual operation. In the latter class of expense the chief factor is the removal of the clogging, caused largely by the accumulation of suspended matters at the surface of the sand. Under ordinary circumstances this is best done

by scraping off, as occasion demands, the upper layer of clogged material, and its subsequent replacement with clean sand.

It is very evident that higher rates of filtration mean a reduction in the first cost of a plant, and, accordingly, in the subsequent annual expense of interest and sinking funds. With regard to the removal of clogging, however, higher rates do not mean a reduction of cost, because it has been learned that the amount of clogged sand removed per 1,000,000 gallons of effluent is practically independent of the rate of filtration, other conditions being equal (see 1892 report, page 463).

The economy of higher rates of filtration, therefore, varies with local conditions, according to the relative sizes of the two principal items of expense, as noted and discussed above. No attempt will be made to discuss the details of cost, but it may be stated that, in the light of our present knowledge, obtained from numerous and long-continued experiments, the cost of rendering by filtration a polluted water supply safe for drinking purposes is considerably less than was formerly supposed to be the case.

The Effect of Different Methods for the Removal of Clogging of Filters upon Their Bacterial Efficiency.

From the discussion of the last topic it is clear that the principal factor of expense in the actual operation of a filter is the removal from time to time of a clogged layer of surface sand. This subject is one of prime importance from a hygienic point of view, because it appears from the results of a portion of our experiments, and from European experience, that this process may cause a diminution in the power of the filter to remove bacteria.

The *average* bacterial results which have been obtained during the past year, just after the removal of clogging at the surface of filters, show that there has been an increase in the numbers of bacteria in the effluents, as was the case under similar circumstances in 1892 and 1893. It will be recalled that in 1893 in about half of the cases of the removal of clogging by scraping off the surface layer, there was no appreciable diminution in the bacterial efficiency of the filter, following this treatment. Again, it may be stated that about half of the cases of removal of clogging in 1894 have been followed by practically no change in the bacterial contents of the effluents.

When we consider the reason of the difference in the results of this treatment of filters, we find that it is necessary to make a detailed analytical study of the conditions under which the treatment was carried out. The most prominent factors have been found to be the depth of clogged sand removed from the surface and the manipulation of the filter, when it is first put in operation after draining and scraping, with regard to the mechanical disturbance of the main body of the filtering material.

A discussion of these two factors is presented beyond; but before this is touched upon it remains to be pointed out clearly that the repeated absence of abnormal bacterial results after scraping the surface of a filter is a fact of much significance. Indeed, it is one of the most marked features of the Lawrence results, as compared with those of European investigations.

Owing to the fact that much of the available evidence has been obtained from experimental filters under conditions which perhaps may not be found in all cases to be feasible in actual practice, the significance of the above-mentioned experience is less from a practical than from a theoretical point of view. Its theoretical importance, however, is fundamental, because it shows the inadequacy of the theory which has been generally held in Germany during the past six or seven years, in explanation of the way in which sand filters accomplish the removal of bacteria from water.

Fallacy of the Theory which regards the Sticky Coating of the Surface Layer (Schmutzdecke) of Filters as Indispensable to Satisfactory Removal of Bacteria.

In 1887 the theory was advanced at Berlin, based upon studies of the Berlin filters by Piefke, Flugge and Proskauer, that the dirty layer on the surface of the sand is essential in order to obtain satisfactory bacterial results. This theory has met the general acceptance of Koch, Fraenkel, Bertschinger and other European investigators. A majority of the writers upon this subject are inclined to regard the whole body of sand as serving for the most part as an under-drain and support for the surface film, although most of them consider that the main body of sand has a steadying influence upon the process of filtration during times of abnormal conditions.

With regard to the Lawrence experience it may be said that the above-mentioned surface film removes more bacteria in proportion to its thickness than any other layer in the filter. Yet, as was

pointed out in the annual report of the Board for the year 1891, page 607, it exerts very little influence upon the results of filtration in many cases, for the reason that filters under normal conditions will remove the bacteria in the absence of such a surface coating. Abundant proof that the surface film is not indispensable has been obtained from several lines of observation, as follows: —

1. The most striking and convincing proof that the surface film is not necessary is found in the case of intermittent filters, the surfaces of which are allowed to uncover and to be exposed during the day to the action of light and the direct rays of the sun. Under these circumstances the surface film has repeatedly been observed to dry, crack and peel, leaving considerable portions of the surface uncovered by the coating characteristic of continuous filters. During the several years in which these investigations have been carried on repeated instances have been noted where parts of the surface films of intermittent filters have floated upon the surface of the water after the resumption of filtration following a period of draining and of rest. Yet in the case of many intermittent water filters which have been carefully operated, numerous and repeated bacterial analyses have failed to reveal any appreciable increase in the numbers of bacteria in the effluents.

2. In the course of our studies of continuous filters of fine or medium-fine sand at times of clogging it has been noted in more than one hundred instances that it is possible under certain conditions to scrape off the upper layers of the filters to a depth of 0.10–0.30 inch without causing a diminution in the bacterial efficiency. So far as practical results on a large scale are concerned, the objection may be raised that the given conditions were impracticable or even impossible to adopt. It is not our purpose at this point to discuss practicability, but rather to insist, for the sake of establishing correctly the fundamental principles of filtration, that conditions do exist whereby normal and very satisfactory removal of bacteria may be obtained when a coating over the surface sand is practically if not completely absent.

3. Another line of evidence, which bears directly upon the point in question, is furnished by the observations from several of the filters of coarser material that they did not give the normal bacterial results, which were subsequently obtained, during the first months of their operation, even when the surface coating was thick enough to completely clog the filters.

4. From studies of the results of analyses of sand samples taken at different depths from the several filters it has been learned that the amount of organic matter found at 1 inch below the surface ranged from 20 to 50 per cent. of that in the clogged surface layers, $\frac{1}{4}$ inch in depth. In the case of Filter No. 18 A, which has been in operation for five years, the amount of organic matter at a depth of 3 inches was also about 50 per cent. of that at the surface. These chemical results, together with the results of bacterial analyses, have a direct bearing in this connection, because of the important part played in filtration by the organic films arranged around those sand grains situated beneath the surface, as has already been referred to on page 592.

Bearing in mind the facts set forth in the four preceding paragraphs, the significance of the opening remarks under this chapter on the removal of clogging of filters becomes clearer, and it is plain that a discussion from a practical point of view of the influence upon bacterial efficiency of the removal of clogging consists principally of a consideration of the two chief factors, as follows: —

1. The depth of material which is removed from the surface by scraping.

2. The mechanical disturbance of the main body of sand, causing to a greater or less degree a separation from each other of the grains with their coatings, and which may be brought about either in the process of scraping or in the subsequent process of refilling the filter and putting it in operation.

Suggestions based on our experience for overcoming the latter difficulty are also offered as a part of the discussion.

Before passing from the theoretical to the practical side of this question, it is instructive to note that Reinsch,* in his studies of the Altona filters since the prevalence of cholera in that immediate vicinity, states that too much significance to the surface coating has been given by earlier German investigators. This confirmation of our experience, first stated in the report of the Board for 1891, is of interest, because, so far as our knowledge goes, it is the first one coming from Germany.

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* Reinsch. Die Bakteriologie im Dienste der Sandfiltrationstechnick. *Centralblatt für Bakteriologie und Parasitenkunde.* Band XVI., page 891. Nov. 27, 1894.

The Effect of the Removal of Different Depths of the Surface Layers of Filters upon Bacterial Efficiency.

The surfaces of the filters have been scraped one hundred and twenty-five times during the past year to relieve clogging. With the view to learn the nature of the results which would be obtained under a wider range of conditions, the filters have been scraped purposely in numerous instances to greater depths than was the case during former years. For this reason, and the fact that the filters have not been operated in a uniform manner just after the surfaces have been scraped, the task of summarizing the results showing the influence of scraping upon the bacterial contents of the effluents becomes a somewhat difficult one. The following statements, however, will serve to convey a general idea of the results in question.

Of the one hundred and twenty-five scrapings there was no appreciable effect upon the bacterial contents of the effluents in fifty-six cases; in twenty-five cases there was a slight but noticeable increase in the numbers of bacteria in the effluent, but as a general rule the numbers in no case exceeded one hundred per cubic centimeter; and in the remaining forty-four instances the increase in the numbers of bacteria in the effluents after scraping was marked, and the numbers exceeded one hundred per cubic centimeter.

The next table contains a summary of results arranged to show the influence exerted by the depth of material removed from each filter at the several scrapings. As a matter of convenience, the depths are divided into six classes. The bacterial results themselves are classified after the methods adopted in the preceding paragraph, and are designated as A, B and C, respectively. That is to say, Class A means that there has been no appreciable effect upon the bacterial efficiency; to Class B belong those results in which there has been a distinct increase in the numbers of the bacteria in the effluent but in which the numbers seldom, if ever, exceeded one hundred per cubic centimeter; and by Class C it is to be understood that the bacterial increases in the effluents have been marked, and have repeatedly exceeded the above-mentioned limit.

A Summary showing the Effect of the Removal of Different Depths of Sand from the Surface of the Several Filters upon Bacterial Efficiency, arranged according to the Foregoing Classification.

Number of Filter.	Number of Scrapings.	Depths removed from Surfaces (Inches). Less than 0.36. A.	B.	C.	0.36-0.50. A.	B.	C.	0.51-0.70. A.	B.	C.	0.90-1.10. A.	B.	C.	1.25-1.50. A.	B.	C.	2.0-3.0. A.	B.	C.
3 B.*,	11	-	3	-	1	-	1	3	-	3	-	-	-	-	-	-	-	-	-
8 A.,	9	2	2	1	1	-	-	-	-	-	2	-	1	-	-	-	-	-	-
18 A.*,	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
33 A.,	5	3	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
38,	10	5	1	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
41,*	8	5	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
42,	7	3	1	1	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-
43,	6	-	1	2	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-
44,	16	4	-	1	1	2	-	5	-	-	-	-	1	-	-	1	-	-	1
45,*	4	1	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-	-	-
46,	8	3	-	1	1	1	1	-	-	1	-	-	-	-	-	-	-	-	-
47,*	19	2	3	2	1	1	4	1	-	-	-	1	-	-	-	2	-	-	2
48,	5	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	3
49,	8	1	-	-	2	2	1	1	1	-	-	-	-	-	-	-	-	-	-
50,	6	-	-	1	1	1	2	1	-	-	-	-	-	-	-	-	-	-	-
Totals,	125	29	12	10	14	10	11	11	1	4	2	1	3	-	1	10	-	-	6
		51			35			16			6			11			6		

* Intermittent filters.

Notwithstanding the fact that the data in the last table are complicated by varying conditions at the time of treatment to relieve clogging, the above results are sufficient to indicate clearly that within certain limits the effect of scraping upon bacterial efficiency becomes more marked as the depth increases. Until the scraping reaches a depth of about 1 inch the evidence at hand goes to show that the influence of depth of removal is comparatively slight and may be almost completely disguised by other factors and conditions. With depths of more than 1 inch the influence of the removal of upper layers of the filter upon the bacterial contents of the effluent is almost uniformly a marked one.

The best method which has been found to reduce to a minimum a diminution in bacterial efficiency at the time of scraping is outlined beyond. At this time it remains to be pointed out that as the depth of material removed increases, not only do the numbers of bacteria in the effluent increase but the period of lessened efficiency also becomes longer.

In a majority of instances the results in the preceding table are averages of two to four bacterial analyses made at times when the first portion of crude river water, which was applied to the filter after scraping of the surface, reached the effluent pipe. In passing it may be noted that this period has been found as a general rule to be one when diminished bacterial efficiency after scraping is most marked. With the view to learn more accurately the behavior of the filters under this treatment, twenty-eight series of analyses of from five to fifteen samples each have been made.

There are presented in the next table the results from ten of the above-mentioned series of analyses. It is instructive to note that in some instances there is no evidence at all of diminution in the efficiency of the filters to remove bacteria. Where there was a decrease in bacterial efficiency it is seen that in some instances the decrease was found to last for only a very few hours; while in other and more marked cases the diminution continued for several days, as referred to above. The number of bacteria in the applied river water refers to the date on which the scraping took place.

Individual Results of Ten Representative Series of Bacterial Analyses to show the Effect of Scraping upon Bacterial Efficiency.

[Bacteria per cubic centimeter.]

NUMBER OF FILTER,	3 B.*	33 A.	38.	41.*	42.	44.	46.	47.*	49.	50.
Depth scraped from surface (inches),	1.00	0.36	0.19	0.30	1.07	0.52	0.53	0.34	0.41	0.49
Rate (million gallons per acre daily),	5	2	3	2	3	7.5	2.5	7.5	10	5
Date (1894),	Oct. 3.	Oct. 15.	Oct. 8.	Nov. 1.	Nov. 10.	Oct. 25.	Nov. 26.	Sept. 24.	Oct. 31.	Oct 29.
Bacteria in river water,	47,700	6,600	16,800	3,800	5,900	1,600	10,600	6,300	4,300	3,700
In effluent just before scraping,	57	40	34	8	153	20	37	34	41	77
In effluent just after scraping,	54	-	36	18	360	50	30	42	60	80
1 hour after scraping,	50	-	27	10	595	55	231	75	67	84
2 hours after scraping,	59	-	19	13	690	60	124	72	110	91
3 hours after scraping,	60	-	31	11	567	31	131	55	95	50
4 hours after scraping,	55	176	20	6	595	43	130	60	93	115
5 hours after scraping,	65	-	24	17	490	38	104	37	100	110
6 hours after scraping,	177	235	22	8	525	40	78	56	83	125
7 hours after scraping,	280	-	-	13	560	35	-	60	81	120
8 hours after scraping,	350	-	-	11	562	38	-	50	75	75
9 hours after scraping,	446	-	-	11	340	41	-	62	100	140
10 hours after scraping,	-	110	19	10	420	-	-	-	103	98
24 hours after scraping,	387	35	31	22	-	40	36	54	54	40
48 hours after scraping,	84	26	50	9	330	40	50	-	43	46
72 hours after scraping,	31	20	63	12	370	44	-	-	32	43

* Intermittent filters.

The effect of scraping will be further discussed beyond. As it is next desired to present the accumulated evidence upon the effect of raking the surfaces of water filters, this topic will be dismissed for the present with the statement, which is made plain by the last table, that in studying the effect of scraping upon bacterial efficiency the question of conditions under which the treatment is made is a matter of prime importance.

The Effect upon Bacterial Efficiency of Raking the Surfaces of Filters to a Depth of about 1 Inch to relieve Clogging.

In order to learn whether or not it would be more economical to rake the surfaces of filters when clogged, rather than to uniformly scrape them, about one-half of the filters have been subjected to the former treatment during the fall months. It has been the custom to rake the surface, whenever it is clogged, to a depth of about 1 inch; eventually there comes a time of course when the upper inch contains so much sediment and stored organic matter that it is necessary to remove it by scraping, as in the case of sewage filters. At the outset of this special experiment it was thought that perhaps this treatment would increase the yield of effluent per unit volume of sand removed from the surface. The reason for this belief lay in the fact that where 0.5 inch or so is removed by scraping the lower portion of the removed layer contains less clogging material than the upper layer. By means of raking it was thought that possibly the entire layer to be removed could be more uniformly clogged, and thereby the cost of operation of the filter decreased.

The surfaces of the filters have been raked seventy-five times to relieve clogging during the past year. In thirty-three cases no appreciable diminution in bacterial efficiency has followed this treatment; there was a slight decrease in the power of removal of bacteria by the filters in twelve cases, but in practically none of these instances did the number of bacteria exceed one hundred per cubic centimeter; but in the remaining thirty cases the diminution was marked, and exceeded the above-mentioned limit with regard to numbers of bacteria in the effluent.

For the sake of convenience in presenting a more detailed statement in tabular form of the bacterial results obtained from raking, the same classification which was adopted in the case of the results from scraping is used in the following table, in which the three grades of results described in the foregoing paragraph are known as A, B and C, respectively.

A Summary of Results showing the Effect of Raking upon the Bacterial Efficiency of Filters.

Number of Filter.	Number of Rakings One Inch Deep.	A.	B.	C.
3 B,*	18	16	1	1
7 A,	4	2	-	2
8 A,	11	4	4	3
18 A,*	6	2	-	4
33 A,	0	-	-	-
38,	0	-	-	-
41,*	0	-	-	-
42,	10	2	1	7
43,	8	2	-	6
44,	1	1	-	-
45,*	15	4	5	6
46,	0	-	-	-
47,*	2	-	1	1
48,	0	-	-	-
49,	0	-	-	-
50,	0	-	-	-
Totals,	75	33	12	30

* Intermittent filters.

Comparison of the available results from raking the surfaces of filters to a depth of about 1 inch to relieve clogging with those from scraping the surfaces to an average depth of 0.65 inch shows that there is substantially no difference in the effect upon the bacterial contents of the effluents, although the numbers themselves when precisely considered indicate that there is a slight advantage in favor of scraping. After this method had been followed for some time it was learned that the economical results obtained during the first few weeks of application would not continue, because it became necessary eventually to scrape off more than the upper inch which was disturbed by raking, in order to remove the clogged layer at the junction of the disturbed and undisturbed layers. From a hygienic point of view this treatment was unfortunate, because it caused a marked diminution in bacterial efficiency at the time of scraping to a depth of more than 1 inch. It is possible that somewhat better results might have been obtained if the rakings had been progressive, that is to say, if the surface was raked about 0.5 inch in depth the first

time and a little deeper on each subsequent occasion. But, all things considered, the treatment of clogged surfaces of water filters by raking does not appear to be so successful as by scraping, under the conditions which exist at Lawrence.

The Effect of Spading over the Surface of a Filter to a Depth of 6 Inches, upon Bacterial Efficiency.

On November 28 the surface of intermittent Filter No. 3 B was spaded over to a depth of about 6 inches for experimental purposes. The diminution which it caused in the bacterial efficiency was very marked, and continued to be so until and after December 6, when the surface became clogged. The bacterial results were so abnormal that for the period November 28–December 6 they are presented in the next table. During this time the number of bacteria in the applied river water averaged about 12,000 per cubic centimeter. As will be seen in the more complete bacterial tables beyond, it was nearly three weeks before normal results were obtained.

Bacteria per Cubic Centimeter in Effluent of Filter No. 3 B.

Date.	Hour.	Bacteria.	Remarks.
1894.			
Nov. 28, . . .	8.00 A.M.	150	Before spading.
28, . . .	12.30 P.M.	1,680	Spading completed and water applied from the top at 10.50 A.M. Outlet gate was not closed.
28, . . .	2.00 P.M.	2,596	
28, . . .	3.00 P.M.	980	
28, . . .	4.00 P.M.	1,260	
28, . . .	6.00 P.M.	1,120	
30, . . .	-	1,300	This and remaining numbers are averages of four analyses.
Dec. 1, . . .	-	735	
2, . . .	-	-	
3, . . .	-	569	
4, . . .	-	346	
5, . . .	-	339	Surface clogged again.

In this connection it is interesting to recall that the disturbance to a depth of 1 foot in the case of Filters Nos. 33 A and 41 was followed by only very slight and temporary increases in the bacterial contents of the effluents, as was noted in the 1893 report, page 466.

On the Most Efficient Method of Putting Filters in Operation after Treatment to Relieve Clogging.

In a majority of cases the method of scraping the small continuous experimental filters, as was noted in the last annual report of the Board, has been as follows: the water above the sand has been siphoned off and the filter allowed to drain until the water stood about an inch below the surface of the sand. The outlet has then been closed, the surface scraped and water slowly applied from the top. When approximately the normal depth of water covers the sand the outlet gate has been opened so that the filter should yield an effluent at the normal rate of filtration.

While under ordinary circumstances this treatment of the in-door experimental filters has caused no marked or serious change in the bacterial contents of the effluents, it is an altogether different matter to relieve clogging in a safe and satisfactory manner in the case of a large filter in actual practice. The reason of this difference is two-fold: first, because it is necessary, in order to get the upper layers of the filter sufficiently dry to walk upon, to lower the water to a greater depth beneath the surface, thereby furnishing an opportunity for mechanical disturbance of the main body of the filtering material when its pores are again filled with water; and, second, because the depth which would be scraped from the surface of a large filter appears to be greater than that which has been removed with a trowel from the smaller experimental filters, in a majority of instances.

In addition to the comparison of conditions in the case of the small (in-door) experimental filters and of large filters in actual practice, with regard to the problem in question, it may be stated here that there would be a wide variance in the conditions of filters in actual practice. Prominent among these varying points would be the construction of the filter, such as its area, and the size, depth and chemical composition of its material, the age of the filter, the rate of filtration, the composition of the unfiltered water and the temperature, with other climatic conditions. All of these factors should apparently be taken into consideration in deciding upon a definite and satisfactory method of procedure.

The most valuable results which have been obtained from the experimental filters, so far as service as a guide for the treatment of large filters at the time of scraping is concerned, are those furnished by Filter No. 8 A, constructed in September, 1893. This continuous

filter, it will be remembered, is about 17 feet in diameter, and is placed out of doors, without protection from the weather. During the first half of the past year the rate of filtration was 2,000,000 gallons per acre daily and for the balance of the time it has been 5,000,000 gallons. It has been the custom, as a general rule, when the filter needed scraping to shut off the river water at the top in the early morning, at 5 or 7 A.M. The water would drain out slowly with the outlet gate wide open.

Various treatments, from this step to the end, have been tried, and the following has been found to be the most satisfactory: with "square-pointed" shovels the upper layer to a depth of about 0.5 inch has been removed; and then, in order to level the surface and remove the prints of the boot-heels of the workmen, the surface has been raked to a depth of about 1 inch. If water were now applied at a rapid rate either from the bottom or to the top of the filter, and filtration begun as soon as the pores were filled, there would in all probability be quite a marked diminution in the bacterial efficiency.

The most successful method of driving the air from the pores without disturbing the arrangement of the main body of filtering material has been found to be the application of filtered water to the bottom of the filter from late in the afternoon until the next morning, or at a rate of a little less than 1,000,000 gallons per acre daily. On the morning after scraping, river water has been applied at the top and filtration begun at the normal rate. This method was recommended in the 1893 report, and has been used with very satisfactory results, under the existing conditions, during the past year.

A possible objection to the above method has suggested itself, in that exposure of the surface for a period of nearly twenty-four hours in some climates and under some conditions might be a disadvantage. With this view it may be added that after scraping the surface of Filter No. 8 A the filter in some instances has been filled with river water from the top at the rate of about 2,000,000 gallons per acre daily. The outlet is kept closed, and when the normal depth of water is on the filter it is allowed to remain in this condition for about twelve hours. This method has also been found to be satisfactory when carefully carried out.

In a certain sense the application of water to the top of a filter with a closed outlet causes it to fill from the bottom upward, owing

to the lateral and upward motion which the water possesses of necessity when applied to one place on the surface of a filter. While this method has been found to be satisfactory with a water containing comparatively little suspended matter, it might not be the case with a very turbid water, owing to an unequal deposition of sediment on the surface, thereby causing an irregular rate of flow through the upper surface of the filtering material.

Limitation to the Theory that the Beneficial Results which are obtained from allowing Water to stand on the Surface after scraping and before starting are largely due to Deposition of Suspended Matter on the Surface of the Sand.

From experience abroad in the operation of large filters which receive turbid waters, it has been found to be advantageous to allow the crude river water to stand for some hours on the surface of a filter just after it has been scraped, with its pores filled with water, and before it is put in operation. It is generally understood that the reason why this treatment is an advantage is because a layer of suspended matter is formed upon the surface of the sand.

Beneficial results from allowing Merrimack River water to stand on the surface of freshly scraped filters, with closed outlets, have been noted. The special point, however, to which it is desired to call attention at this time is that this treatment has been found to be advantageous even in those instances when the Merrimack River water has contained, comparatively speaking, practically no suspended matter.

The Effect of Winter Weather upon Bacterial Efficiency.

So far as our present knowledge goes no direct influence of winter weather upon the removal of bacteria by filtration has been noted.

It is true that in several instances unsatisfactory bacterial results have been obtained during the winter months from Filters Nos. 3 B and 8 A, which are unprotected from the weather. In all cases it is believed that these results have come from conditions which are independent of the season, or from circumstances which have affected the results indirectly and which do not of necessity belong to the process of water filtration. Prominent among the circumstances in question has been the occasional freezing of the surface of intermittent Filter No. 3 B at times when it has been drained in order to allow the pores to fill with air. The only remaining condition lead-

ing to abnormal bacterial results is the disarrangement of the surface of the sand, caused by the removal of the ice from the surface of the water. In several instances the broken ice has unavoidably ploughed the surface of the sand and caused the water to pass through the sand at unequal rates of filtration.

The relation of the small in-door experimental filters to winter weather has already been fully explained on page 579. For temperatures of the air in winter and the local precipitation of snow and rain, reference is made to the tables on pages 526 and 457.

The Effect of Depths of Filtering Material upon Bacterial Efficiency.

The results obtained during 1893 upon this point showed that, while the deepest filters were most efficient in the removal of bacteria, the shallower ones were fairly satisfactory, on the whole, and very efficient under favorable conditions. Particularly instructive results were obtained from Filter No. 39, which contained above the 5 inches of under-drain (stones, gravel and coarse sand) only 1 inch of filtering material. The bacterial contents of the effluent of this filter compared favorably with those from 5-foot filters when there was no disturbance of the shallow filtering layer; when there was a disturbance the diminution in bacterial efficiency was very marked, as might be expected.

At this time it is interesting to compare the bacterial results from Filters Nos. 38 and 42, which are composed of the same material, and which are 20 and 10 inches deep, respectively. These filters were operated, as described beyond, from May to December 1, at a rate of filtration equivalent to 3,000,000 gallons per acre daily. The number of bacteria in the applied river water averaged 19,900 per cubic centimeter, while the average numbers of bacteria in the effluents of the two filters were 37 and 105, respectively. The usual numbers of bacteria obtained under normal conditions from these filters are lower and more nearly equal, as will be noted in the tables of analyses beyond, and the significance of the above averages is that Filter No. 42 felt more severely the effect of disturbing influences which were also more numerous than in the case of Filter No. 38.

Instructive results have also been obtained from Filter No. 46, which contains 12 inches in depth of sand of an effective size of 0.29 millimeter and which has been operated at a rate of 2,500,000 gal-

lons per acre daily. The average numbers of bacteria per cubic centimeter in the applied water and in the effluent were 19,900 and 75, respectively. The latter number includes some abnormal results, but fewer than in the case of either Filter No. 38 or 42.

The normal removal of bacteria by Filter No. 7 A, 2 feet in depth, compared quite favorably on the whole with that of Filters Nos. 3 B and 8 A, which are constructed of 5 feet in depth of the same material. The age of the filters, rate of filtration and other factors differed so that for further information reference is made to the detailed account beyond of the work of the filters.

As the evidence now stands it appears that filters of 2 feet, or even 1 foot, in depth yield practically as satisfactory bacterial results as do deeper filters, provided there is no disturbing influence. There are substantial reasons for the belief that these are not necessarily a part of the process of filtration, but if they do occur their influence upon the efficiency of filtration is not only more marked but also of longer duration in the case of filters 1 to 2 feet deep than with deeper filters.

Owing to the fact that shallow filters may be constructed at a less cost than deep ones the consideration of the most satisfactory depth of filtering materials is an important matter. From the available evidence it is questionable whether it would not be advisable from all points of view to construct filters say 3 feet in depth, and, from the results of this economy in construction, devote more attention to the operation of the filter plant. In this connection it should be borne in mind that filters of 5 feet in depth as well as those 3 feet deep must receive intelligent operation and careful supervision in order that they may produce uniformly satisfactory results from a hygienic point of view. Final discussion upon this point is deferred until more evidence is available, and it may be mentioned that this is one of the most important questions to be investigated hereafter.

Reason why Deep Filters are more Uniformly Efficient than Shallow Ones.

This question has received considerable attention during the past year. For some time it has been known that under some circumstances, other conditions being equal, the effluents of filters from 1 to 2 feet deep have contained as little organic matter and as much nitrogen in the form of nitrates as effluents from deeper filters.

This has not been found to be so under all conditions of the Merrimack River water at all seasons of the year, however, although numerous results have been obtained which would point in that direction. Nevertheless, comparative study of the individual results of chemical and bacterial analyses of effluents appears to fail to attribute differences in bacterial contents of effluents of filters of different depths to differences in the composition of the effluents themselves. Further investigations upon the filtering materials themselves have therefore been made with the view to obtain additional light upon this problem.

The results in detail of chemical and bacterial analyses of samples of sand taken from different depths of the various filters have been presented on pages 601–604. After the discussion which has been given on the effect of age of filters, of surface coatings, of deep scraping and raking upon bacterial efficiency it is hardly necessary at this point to do more than refer to the importance of the organic matter which is arranged as films around the sand grains.

In order to show, for the purpose of discussion of the problem in question, the amount of organic matter and the bacteria found in the materials of filters in successful operation there has been prepared the following table, which contains the average results from ten five-foot filters. Of this number, all of which were in successful operation when examined, four have been intermittent filters; the remainder have been operated continuously.

Table showing the Average Results of Chemical and Bacterial Analyses of Sand from Ten Filters, Dec. 1, 1894.

Depth from Surface (Inches).	Organic Nitrogen. Parts per 100,000 by Weight of Dry Sand.	Bacteria per Gram.	Depth from Surface (Inches).	Organic Nitrogen. Parts per 100,000 by Weight of Dry Sand.	Bacteria per Gram.
0-¼, ...	20.0	6,600,000	24, ...	2.3	47,000
1, ...	9.5	1,940,000	36, ...	1.6	35,000
3, ...	6.4	720,000	48, ...	1.2	29,000
6, ...	4.7	300,000	60, ...	1.2	26,000
12, ...	4.0	90,000			

Upon examination of these results with regard to their relation to the influence of depth of material upon bacterial efficiency it is well to remember that marked increases in the bacterial contents of the efflu-

ent occur when the surfaces are scraped to a depth of 2 or 3 inches or when spaded over to a depth of 6 inches, as in the case of Filter No. 3 B (see page 629).

This table shows that the organic matter and bacteria are highest in the portion of the filter where the greatest amount of work is done, and the upper foot shows evidence of having done by far the largest amount of work. The next two feet show the results of operation but in a diminishing degree.

In passing it may be stated that in the discussion beyond upon the effect of method of application of water on chemical purification evidence will be found that it is in the upper portion of the filter that nitrification chiefly occurs. From the results of our studies of shallow filters there is reason to believe that the composition of filters 1, 2 or 3 feet deep, other conditions being equal, would be similar to corresponding upper portions of 5-foot filters, as shown in the last table.

Let us turn back to the last table and compare the amount of organic matter stored in the lower portion of the filters. It will be remembered that the amount of organic matter serves to indicate the degree to which gelatinous films are arranged around the grains; and also that the sand contained originally a somewhat variable amount of organic matter which averaged about 0.85 part per 100,000 by weight of dry sand. The organic matter arranged as films around the grains of the third foot of material from the top is seen to be much in excess of the original amount; the fourth foot contains a much smaller and a gradually decreasing amount; while in the fifth foot the quantity is very slightly in excess of that originally present and there is as much at the bottom as at the top of this section of the filters.

The evidence at hand indicates that the films of organic matter arranged around the grains in the lower portion of deep filters are an important factor in the explanation of the greater and more uniform efficiency of deep filters in the removal of bacteria. It is possible that there are other important factors, but none have been noted which compare in importance with the one mentioned.

The Effect of the Amount of Loss of Head upon Bacterial Efficiency.

In the last report it was stated that, contrary to some European experience, the experimental filters at Lawrence under ordinary conditions show no diminution in the removal of bacteria when the loss of head of measurement of the frictional resistance to the passage of water reaches 70 inches. The results obtained during 1894 confirm the earlier ones and make it plain that high numbers of bacteria in the effluents do not of necessity follow high losses of head. From our experience with water filters it may be added that in some cases abnormal bacterial results may be due to one or both of the following causes : —

1. To unequal rates of filtration of water through the surface of the filtering area. This state of affairs could be caused by several conditions and would probably be more marked with a turbid than a clear water, owing to the unequal deposition of sediment upon the surface of the sand.

2. The lack of oxygen in continuous filters, which might exhibit a growth of bacteria at a time when the accumulation of organic matter at the surface was great and when necessarily the loss of head was also great.

Beginning September 6 a change was made in the operation of the filters by which the maximum loss of head was reduced 16 to 18 inches. In the case of 5-foot filters this means that the maximum loss of head was reduced from 70 or 72 inches to 52 or 54 inches. The reasons why this experiment was undertaken were as follows: from the description and results of the operation of water filters in this and preceding reports it is plain that the mechanical disturbance of the main body of filtering material, at the time of filling filters just after scraping, and especially in the case of intermittent filters just after the period of draining and of rest, is a matter which must receive careful consideration in the maintenance of uniform bacterial efficiency. It was thought that an arrangement of the trap on the outlet pipe, whereby the under-drains and the lower foot of filtering material would constantly have their pores filled with water, might aid in maintaining uniform efficiency by keeping the lower portion of the filter comparatively free from the disturbances noted.

Before the experiment was undertaken it was learned by actual experiment that nitrification took place for the most part in the

upper portion of the filtering material. The evidence at hand also showed that the loss of head increased very quickly, comparatively speaking, from 55 to 70 inches, and that the total yield of effluent between scrapings at the former limit (55 inches) would be more than 90 per cent. of that of the latter.

It has been found that from a bacterial point of view the large filters placed out of doors feel the effect of unequal rates of filtration, due to the presence of channels in the sand, more than is the case with the smaller (20-inch) filters. Accordingly, an outline of the results obtained from this treatment of Filter No. 3 B will be given.

On September 6, the trap on the outlet of intermittent Filter No. 3 B was raised so that the lower foot of sand should remain saturated. The rate of filtration was 5,000,000 gallons per acre daily, and with the exception of the higher trap no change in the method of operation was made. The bacterial results seemed to indicate that the ability to remove bacteria was somewhat greater after this change, especially during the first few days after the surface of the filter had been scraped. In support of this there are presented in the following table the average bacterial results by weeks for the four weeks preceding and the four weeks following this change of treatment.

Table showing a Comparison of Weekly Averages of the Number of Bacteria per Cubic Centimeter in Samples taken at Different Hours of the Day from the Effluent of Intermittent Filter No. 3 B.

Aug. 13-Sept. 8, 1894.

Week Ending—	Applied Water.	Effluent.		
		8 A.M.	12 M.	4. P.M.
1894.				
Aug. 18,	2,600	34	49	27
Aug. 25,	4,700	55	36	172
Sept. 1,	3,000	19	36	25
Sept. 8,	4,000	51	112	58
Averages,	3,600	40	58	70

Sept. 10-Oct. 6, 1894.

Week Ending—	Applied Water.	8 A.M.	12 M.	4. P.M.
Sept. 15,	12,200	49	43	31
Sept. 22,	16,700	13	35	26
Sept. 29,	49,700	34	42	28
Oct. 6,	65,800	111	94	107
Averages,	36,100	52	53	48

It is probable that other factors may have had some influence in producing the more uniform results obtained during the latter part of the period covered by the results in the last table. But it is believed that the more satisfactory results obtained after reducing the available head were due in part to this change.

With the large continuous filters, Nos. 7 A and 8 A, the influence of the higher traps was less marked than in the case of the intermittent filter referred to above, but there were indications that this treatment aided in maintaining more nearly normal results just after scraping. With the smaller 20-inch filters the effect of the change was still less marked, because they are too small to feel seriously the influence of unequal rates of filtration. There has been a slight improvement, however, in the bacterial results from the small intermittent filters of coarse materials, Nos. 47 and 18 A.

As the area of filtering surfaces is increased it is probable that the beneficial effect of some such treatment as this would become more marked. It ought not to be forgotten, however, that the lowest foot of a water filter appears to be the least efficient in the removal of bacteria. Owing to the possibility of complications with other important factors and to the short duration of these experiments it does not appear advisable to draw any definite conclusions as to the merits of this line of treatment.

The Effect of Size of Sand Grains upon Bacterial Efficiency.

The evidence which has been obtained with respect to the size of sand grains plainly shows that the chief points to be considered in this connection are as follows :—

1. The effect of differences in the size of grains of filtering materials is shown to a marked degree by the differences in length of time required for filters of new material to yield effluents of normal bacterial contents.

2. As the size of sand grains increases the effect upon bacterial efficiency of such disturbing conditions as deep scraping, unequal rates of filtration, etc., becomes more marked, even in the case of filters which have been several years in operation.

3. This last fact is well brought out by a study and comparison of the results obtained from Filters Nos. 18 A and 50, constructed of sand of an effective size of 0.48 millimeter. The marked superiority during the summer and early fall of Filter No. 18 A which

was put in operation in September, 1889, points clearly to the fact that filters as they grow old in service resemble finer ones more and more.

Owing to the complications arising from differences in chemical composition of sand grains, age of filter and other factors, it seems unnecessary to tabulate the results on this point. More light will be obtained from the study of the results in detail as found beyond.

The discussion upon this topic may be closed with the statement that under the conditions which have prevailed at Lawrence satisfactory removal of bacteria from water may be obtained from sand of a size which must be uniform throughout the filter but which may range from 0.14 to 0.38 millimeter for effective size. Sand as coarse as 0.48 millimeter effective size (Filters Nos. 18 A and 50) requires a longer period of operation to yield normal results.

The Effect of the Composition of the Unfiltered Water upon Bacterial Efficiency.

The data upon water filtration have been obtained exclusively with the Merrimack River water, although there has been considerable variation in the conditions under which it has been studied. Not only have the differences arising from changing seasons and from storms and freshets been noted, but considerable attention has been given during the past year to the filtration of the river water after it has passed through the filter and distributing system of the Lawrence Water Works.

Comparison of the bacterial results obtained from the filtration of the Merrimack River water and the Lawrence city (filtered) water has been given on pages 589, 590, where it was shown that the former water, containing more organic matter in solution, offered some marked advantages, from a hygienic point of view, for treatment by filtration.

The amount of free oxygen which is dissolved in the unfiltered water is a matter of importance, and the quantity varies not only in the case of different waters but in the case of the same water at different seasons of the year. The chief significance of the amount of oxygen is its relation to the amount of organic matter present in the unfiltered water. This point should be considered in deciding

whether a water filter should be operated intermittently or continuously.

The available evidence shows clearly that there are some waters which are saturated with oxygen and contain a small amount of organic matter, and which may be filtered by the continuous method under proper conditions with thoroughly satisfactory bacterial results. On the other hand, the successful filtration by the ordinary continuous method of a water which contains much organic matter and very little or no free oxygen is absolutely out of question.

The Effect of the Method of Application of Water to the Filters upon Bacterial Efficiency.

In 1894 a change was made in the method of operating filters intermittently, and this change will first be described, together with its effect upon the removal of bacteria. The continuous filters have of necessity been operated in substantially the same manner as in former years.

During 1893 the intermittent filters were operated as follows: at 5 A.M., after draining over night, the untrapped outlet was closed and the water turned on at the top, causing the air in the pores of the sand to be forced out at the surface. When the surface was covered and the larger part of the air driven out of the pores (about 7.30 A.M.) the gate of the outlet pipe was opened to give the prescribed rate and the surface kept covered with water. At 9 P.M. the water was shut off and the filter allowed to drain. Under these conditions of operation it was shown in the 1893 report that the intermittent filters gave less uniform and less satisfactory bacterial results than continuous filters, owing to mechanical disturbances of the sand by the escaping air.

Beginning the first week in June, 1894, the method of operation of intermittent filters was changed as follows: at 6.30 A.M. the application of water was stopped and the filter allowed to drain for two hours from the time when the surface was first uncovered. Water was again applied and the gate of the outlet pipe kept constantly open. This caused the air to be forced downward through the outlet and largely prevented disturbance at the surface. The bacterial purification became more uniform, as is brought out by the following table, in which are given the weekly averages of the numbers of bacteria per cubic centimeter in the applied water and in the effluents

of intermittent Filter No. 3 B, and of its continuous mate, Filter No. 8 A, for the five weeks preceding and the five weeks following this change in method of operation. The conditions were as nearly alike as possible during this period, except the manner of application of water to Filter No. 3 B.

Table showing a Comparison of Weekly Averages of the Number of Bacteria per Cubic Centimeter in Samples taken at Different Hours of the Day from Effluents of Intermittent Filter No. 3 B and Continuous Filter No. 8 A.

April 30–June 2, 1894.

Week Ending—	Bacteria in Applied Water.	Intermittent Filter No. 3 B.				Continuous Filter No. 8 A.			
		8 A.M.	11 A.M.	2 P.M.	4 P.M.	8 A.M.	11 A.M.	2 P.M.	4 P.M.
1894.									
May 5, . . .	2,800	94	72	54	39	29	31	29	34
May 12, . . .	4,700	72	54	47	57	28	25	27	25
May 19, . . .	7,100	128	142	82	66	29	27	28	28
May 26, . . .	12,700	123	85	81	62	28	29	29	22
June 2, . . .	4,900	135	158	114	69	35	35	39	38
Averages, . .	6,400	110	102	76	59	30	29	30	29

June 4–July 7, 1894.

Week Ending—	Bacteria in Applied Water.	8 A.M.	11 A.M.	2 P.M.	4 P.M.	8 A.M.	11 A.M.	2 P.M.	4 P.M.
June 9, . . .	5,700	97	90	142	93	50	37	51	38
June 16, . . .	5,100	41	51	42	47	29	26	33	30
June 23, . . .	7,700	68	73	143	90	30	26	21	17
June 30, . . .	11,600	51	64	115	75	37	52	40	68
July 7, . . .	4,900	33	48	60	50	14	14	15	19
Averages, . .	7,000	58	65	100	71	32	31	32	34

These results show that the duration of the period of higher numbers after the interval of rest was several hours shorter by the new than by the old method of treatment, but the change in operation did not do away at all times with irregular bacterial results.

In studying the latter part of the last table it will be seen that during the weeks ending June 16 and July 7 the bacterial results from Filter No. 3 B were very uniform, while there was considerable variation during the other weeks of this period. The explanation of this is that in the two weeks mentioned there was no scraping of the surface, while the influence of this treatment was felt during

each of the other three weeks. From observations of the filter it appeared that for a few days following scraping the water, when applied to the surface after draining, passed through the sand near the point of application at a very rapid rate of filtration, while the surface covered very slowly. When there was an accumulation of sediment upon the surface the water, upon application to the drained sand, distributed itself over the whole surface much more quickly and the action of the whole filter was more uniform. It was repeated observations of this nature that led to the change in the traps, as has been described under loss of head on page 637.

In arranging the bacterial results to show the relative efficiency of intermittent and continuous filters the average results for the entire daily yield of the intermittent filters have been taken. That is, the numbers obtained just after refilling following a period of rest, which have been higher at times than at other periods of the day, have been averaged in the proper ratio with those numbers representing the remainder of the daily (twenty-four hours) flow.

The average numbers of bacteria obtained in this manner from the several pairs of intermittent and continuous filters from September 1 to November 30 inclusive are presented in the table below. From the early portion of the report on water filtration it will be recalled that Filters Nos. 33 A, 41, 43, 44, 45 and 47 were allowed to rest until about July 20, and had attained normal bacterial efficiency again by September 1, when traps were arranged in each case so that the under-drains and lower portion of filtering material were constantly saturated with water. The traps were similarly arranged September 6 on Filters Nos. 3 B and 8 A, which had been in continuous service since the preceding September. In comparing the results from the coarse Filter No. 50 with those from Filter No. 18 A it is to be remembered that the former was constructed July 23, 1894, while the latter was constructed Sept. 17, 1889; the trap to each of those filters was arranged similarly to those of the filters mentioned above.

Table showing Comparison of the Average Number of Bacteria per Cubic Centimeter in Effluents of Continuous and Intermittent Filters.

Date.	September.	October.	November.	Averages.
1894.				
Applied water, ...	20,000	29,000	10,800	19,800
Filter No. 3 B, intermittent, ...	37	61	194	97
8 A, continuous, ...	19	35	147	67
18 A, intermittent, ...	136	330	101	182
50, continuous, ...	283	258	100	214
41, intermittent, ...	16	28	59	34
33 A, continuous, ...	32	150	37	73
45, intermittent, ...	59	165	103	109
43, continuous, ...	108	438	141	229
47, intermittent, ...	118	401	205	241
44, continuous, ...	76	275	51	134

Of the several sets of results presented in the above table those from Filters Nos. 3 B and 8 A are of the most value, owing to the size of the filters and to the marked similarity in many of their features of construction and operation. These results show that the bacterial efficiency of the continuous filter was greater than that of the intermittent filter. Three comparisons, however, of the five given in the last table indicate the number of bacteria were higher in the effluents of the continuous filters ; and the average number of bacteria per cubic centimeter in all of the effluents of the continuous and intermittent filters was 143 and 133, respectively. With regard to uniformity of efficiency the advantage has apparently lain with the continuous filters.

It is evident from the statements made earlier in the discussion on water filtration that all of the average results presented above have been more or less influenced by such treatments as fluctuating rates of filtration, deep scraping and raking, etc., conditions which should be avoided in actual practice. A detailed study of the individual results, furthermore, shows that the normal bacterial results from intermittent and continuous filters are more nearly equal than appears in the case of some of the averages given above.

Conclusions.

All things taken into consideration it appears that the proper conclusion from the evidence obtained upon the point in question is that *satisfactory results with regard to the removal of bacteria from Merrimack River water of the composition possessed during 1894 may be obtained*, *under suitable conditions*, *by either intermittent or continuous filters.*

From our general knowledge of, and experience with, the filtration of sewage and water this conclusion may be extended somewhat. It may be stated that, so far as the amount of ordinary organic matter and free oxygen are concerned, satisfactory bacterial results may be obtained, under proper conditions, from the intermittent filtration of any water even when its composition approaches that of sewage. The unfavorable feature of intermittent filtration with regard to the removal of bacteria has arisen from slightly diminished efficiency at the time when the filters have been refilled after a period of draining and of rest. This has been most noticeable in the case of filters of relatively coarse material which are thoroughly underdrained and operated at comparatively high rates of filtration; and especially at a time just after scraping the surface when the upper layers are porous and allow the water to enter the material rapidly near the point of application.

With regard to the bacterial results from continuous filtration of water, as the process is generally understood, no such statements of as broad a nature as given above can be made because this method is successful only in the case of waters which contain not more than a certain amount of organic matter in relation to the free oxygen which they possess. It may be stated that the Merrimack River water appears at times to approximate this limit very closely. This is most noticeable during the summer months, for reasons which will appear beyond, and especially during the summer of 1892 when it will be remembered that there were evidences in the effluents of marked bacterial growths within the filters.

Chemical Purification of Water and Removal of Color by Filtration.

Of the organic matter in the Merrimack River water 15 to 20 per cent. is usually in suspension, as shown by the results of the determination of the albuminoid ammonia.

All of the suspended organic matter is removed by the filters, and in addition to this a somewhat variable amount of the color and soluble organic matters.

Taking the final averages of all monthly averages of analyses of the several effluents it is found that the removal of color has been 43 per cent.; of albuminoid ammonia, 55 per cent.; and oxygen consumed 44 per cent. of that in the unfiltered Merrimack River water. These results are somewhat better than those obtained during the preceding year. The reason of this seems to be owing in part to the fact that the filters were allowed to rest for a long period and that new sand was put on the surfaces to replace that removed by scraping.

Before presenting and discussing the results more fully it will be well to state that additional light has been obtained as to the method by which organic matter is removed by water filters. It appears that the organic matter to a considerable degree unites with certain constituents of the filtering material; and it is in this form that the organic matter is changed to mineral matter by bacterial action in the presence of free oxygen, rather than when it is a constituent of the water itself on its passage through the interstices of the sand.

The theory just mentioned is particularly serviceable in explaining the somewhat remarkable fact that a filter less than 5 inches in depth has at times yielded an effluent of as good chemical composition as have filters 5 feet in depth. If the theory is true, as appears to be the case, this result is capable of simple explanation on the ground that all of the organic matter which will unite with the sand of the given mineral constituents is found around the grains in the upper five-inch layer, and the material beneath it is out of service in this instance.

A comparison of the efficiency of the several filters in the removal of color and organic matter, as indicated by the albuminoid ammonia and oxygen consumed, is presented in the next table. The rates of filtration are expressed in million gallons per acre daily. The amounts of color and organic matter in the effluents are expressed in percentages of that in the unfiltered water. For further details regarding methods of operation and results of analyses reference is made to the detailed account of the work of the filters beyond.

Table Showing Percentages which the Color, Albuminoid Ammonia, and Oxygen Consumed in the Effluents were of those in the Applied Water.

Number of Filter.	May.				June.				July.				August.				September.				October.				November.			
	Rate.	Color.	Albuminoid Ammonia.	Oxygen Consumed.	Rate.	Color.	Albuminoid Ammonia.	Oxygen Consumed.	Rate.	Color.	Albuminoid Ammonia.	Oxygen Consumed.	Rate.	Color.	Albuminoid Ammonia.	Oxygen Consumed.	Rate.	Color.	Albuminoid Ammonia.	Oxygen Consumed.	Rate.	Color.	Albuminoid Ammonia.	Oxygen Consumed.	Rate.	Color.	Albuminoid Ammonia.	Oxygen Consumed.
3 B,* . .	1.4	72	51	71	2.0	65	49	70	2.8	47	32	59	2.6	33	27	50	3.4	48	35	70	4.0	51	42	52	3.8	69	41	70
7 A, . .	–	–	–	–	–	–	–	–	–	–	–	–	1.2	63	44	77	1.5	50	30	70	2.0	57	47	55	1.8	72	51	76
8 A, . .	1.6	63	48	63	1.6	59	46	62	2.7	44	32	56	2.8	40	29	58	4.0	51	34	73	4.6	51	36	50	3.8	72	53	78
18 A,* . .	–	–	–	–	–	–	–	–	5.0	69	67	84	5.0	53	36	65	5.1	58	38	66	4.7	65	44	75	4.6	84	55	78
33 A, . .	–	–	–	–	–	–	–	–	2.3	52	34	65	1.9	45	33	61	1.9	45	39	64	2.0	60	42	75	2.0	70	45	63
38, . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.9	20	29	44	3.0	34	41	65	2.9	73	55	80
41,* . .	–	–	–	–	–	–	–	–	2.5	52	41	69	2.3	47	29	57	2.0	43	31	55	1.9	46	43	67	1.8	66	50	70
42, . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.9	23	34	48	3.0	56	47	72	2.9	73	60	87
43, . .	–	–	–	–	–	–	–	–	5.0	72	60	84	4.8	37	37	65	4.6	44	35	70	4.7	60	42	90	4.9	80	56	91
44, . .	–	–	–	–	–	–	–	–	7.5	63	60	84	7.4	40	35	65	7.4	34	27	70	7.3	63	51	90	7.3	82	60	93
45, . .	–	–	–	–	–	–	–	–	5.6	61	52	81	5.1	40	38	60	4.7	34	30	70	4.7	65	52	95	4.7	88	62	93
46, . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.3	22	35	48	2.5	58	45	70	2.3	75	54	91
47,* . .	–	–	–	–	–	–	–	–	7.0	66	44	81	7.0	43	37	73	6.9	35	31	70	5.8	63	48	87	5.3	77	67	93
48, . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.8	55	50	75	4.5	80	66	91
49, . .	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7.6	57	51	77	9.5	77	61	91
50, . .	–	–	–	–	–	–	–	–	5.1	19	30	62	4.8	47	44	60	4.8	46	43	70	5.0	65	48	70	4.6	39	56	76

* Intermittent filters.

Comparison of corresponding results in the two preceding reports, to show the effect of rate of filtration, size of sand grain and depth of material, indicated that these had little influence within the limits studied. During the past year there have been times when it appeared that these factors had some weight, under the somewhat wider range of conditions.

Prominent among the factors which seem to be more entitled to consideration in the removal of organic matter are organic composition of water; free oxygen in water; mineral composition of filtering material; age of filters; and temperature.

Effect of the Method of Application of Water upon Chemical Purification.

This problem was investigated with considerable thoroughness in 1893, and in the annual report of the Board for that year it was shown that there was practically the same amount of color, free ammonia and of organic matter, as indicated by the albuminoid ammonia and oxygen consumed, in the effluents of the continuous and intermittent filters. The results obtained during the past year confirm the earlier ones, as is shown by the total averages of comparable results presented in the following table.

Table showing Comparison of Monthly Averages of Chemical Analyses of Continuous and Intermittent Filters.

Intermittent Filters, — August–November, 1894.

[Parts per 100,000.]

Rate of Filtration (Gallons per Acre Daily).	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.
4,273,000, ...	60	.22	.0012	.0081	.28	.033	.0000	.25	65

Continuous Filters, — August–November, 1894.

Rate of Filtration (Gallons per Acre Daily).	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.
4,536,000, ...	60	.22	.0013	.0083	.29	.027	.0000	.26	38

There are only two points in which these results show a substantial difference, and they are the nitrogen in the form of nitrates and the free dissolved oxygen which are higher in each instance in the case of

the intermittent filters. In studying these results careful consideration should be given to the conditions under which they were obtained. The method by which the intermittent filters were operated and the change in arrangement of the traps on the outlet pipes have beeen described on pages 637 and 638.

Intermittent Filter No. 3 B and continuous Filter No. 8 A are larger than the other filters, and exposed to out-door weather and have been regularly in service throughout the year; hence it is instructive to summarize briefly, in this connection, the results of the chemical analyses which are presented beyond. The average yearly results of analyses of the effluents of this pair of filters show the following results, respectively, expresseed in parts per 100,000: color, 0.28 and 0.27; free ammonia, 0.0020 and 0.0019; albuminoid ammonia, 0.0088 and 0.0090; nitrogen in the form of nitrates, 0.0300 and 0.0270; oxygen consumed, 0.29 and 0.28; and percentages of dissolved oxygen 85 and 64. These results, covering the entire year, show even a less difference between the intermittent and continuous filters than in the case of the results presented in the last table.

These differences in the composition of the effluents have received considerable discussion in previous reports but at this time it will be well to review the matter briefly and add to it the additional information obtained during the past year.

Relation of Free Oxygen in Unfiltered Water to Chemical Purification.— Free oxygen and bacterial action are both absolutely necessary for the conversion by filtration of organic matter to harmless mineral matter. The amount of free oxygen present in fresh sewage is insufficient for the purification of sewage by filtration and nitrification and it is absolutely necessary to introduce additional oxygen into the pores of the filtering material. In the case of ordinary waters the amount of organic matter is much less and in many cases, apparently, is not in excess of the amount which can be nitrified by the aid of the free oxygen dissolved in the water.

The amount of free oxygen in the effluents of continuous filters at Lawrence becomes very small at times, although the effluents, as they have flowed through trapped outlets, have never been found wholly lacking in free oxygen. This is shown by the next table, in which are given the average monthly results of determinations of free oxygen in the applied Merrimack River water and in the sev-

eral effluents. In studying these results it should be borne in mind that the amount of free oxygen necessary to saturate water varies with the temperature and ranges from 1.47 parts at 32° F. to 0.81 part at 80° F., expressed by weight in parts per 100,000. In the table below the convenient method is followed of expressing the amount of oxygen in percentages of that necessary for saturation at actual temperatures, but for reference the approximate temperature is also recorded. The fact that the amount of free oxygen in waters is least in summer when the organisms of nitrification are most active is a matter of some significance.

Table showing Per Cent. which Oxygen dissolved in the Applied Water and Effluents was of that Necessary for Saturation at Actual Temperature.

Month.	Temperature. Deg. F.	River Water.	In Effluents of Filters Nos.— 3 B.*	7 A.	8 A.	18 A.*	33 A.	38.	41.*	42.	43.	44.	45.*	46.	47.*	48.	49.	50.
1894.																		
May,	57	86	96	–	70	–	–	–	–	–	–	–	–	–	–	–	–	–
June,	67	80	80	–	77	–	–	52	–	58	–	–	–	55	–	93	53	–
July,	76	69	80	–	37	37	4	40	51	47	15	–	42	40	56	50	43	53
August,	74	52	70	31	31	42	7	43	63	50	15	18	63	41	67	40	43	26
September,	67	58	65	28	41	60	31	44	59	45	4	9	52	43	55	62	61	35
October,	58	68	45	24	26	51	42	37	77	50	42	38	55	46	70	71	70	44
November,	44	88	84	62	70	83	76	78	86	73	71	78	81	85	–	79	80	64
Averages,	–	71	74	36	50	55	32	49	67	54	29	36	59	52	62	66	58	44

* Intermittent.

It will be noted that the effluents of intermittent filters contained much more free oxygen as a rule than those of continuous filters, owing of course to the increased amount of oxygen which entered the pores of the intermittent filters at times of draining and rest.

It will be noted, also, that the effluents of continuous Filters Nos. 38, 42, 46, 48 and 49 contained a large percentage of free oxygen during the summer months. The reason of this is that at that time they received city (filtered) water which contained a slight amount of organic matter capable of removal by oxidation and nitrification under the existing conditions.

Consideration of the Amount of Nitrates in Effluents.

The degree of nitrification is measured of course by the increase in the amount of nitrogen in the form of nitrates in the effluent over that in the unfiltered water. As was shown in last year's report the nitrates in the effluents of continuous filters are reasonably constant throughout the entire day; while in the case of intermittent filters the amount varies to a marked degree. The reason of this is that a portion of the organic matter stored in the sand is nitrified during the period of rest after draining. When water is again applied the nitrates are washed out, giving unusually high amounts for some time, varying according to the rate of filtration. After a time, however, these high nitrates fall to the normal.

Much time and labor have been spent during the past year in studying the relative intensity of nitrification in intermittent and continuous filters, especially during the summer months. During the summer weather the nitrification of Merrimack River water by intermittent filtration is certainly more complete, although the difference in the remainder of the year is slight and sometimes in favor of the continuous filters.

The especial difficulty which had to be contended with during the summer months was the marked variation in the amount of nitrates in the applied river water drawn from the canal. This variation was due to the fact that, as the summer was a dry one and the river was so low that the mills could not be operated on many occasions at night by water power, the canal remained over night filled with still water, and by a series of special experiments it was learned that the nitrates increased during the night to a marked but variable degree.

During the past year it has been the custom to analyze several times each month a series of at least four and usually five samples collected in one day from the effluents of the intermittent filters. The monthly averages of analyses for the year 1894 have been made from representative results from these series.

The following experiment, typical of several which were made during the spring and summer, is instructive in this connection.

The gates on the inlet and outlet pipes of intermittent Filter No. 3 B were closed at 5 P.M. on May 14, and the filter remained out of service with the surface covered with water until 5 A.M. on May 18.

The gates were then opened and filtration resumed at the rate of 2,900,000 gallons per acre daily. Four samples were collected at different hours of the day and analyzed with the following results: —

Intermittent Filter No. 3 B,—May 18, 1894.

[Parts per 100,000.]

Hour.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates.	Nitrites.	
5.15 A.M.,	.18	.0010	.0094	.15	.0560	.0000	.25
8.31 A.M.,	.18	.0006	.0086	.15	.1380	.0002	.22
11.01 A.M.,	.28	.0020	.0154	.15	.0600	.0006	.32
4.01 P.M.,	.32	.0010	.0120	.15	.0300	.0000	.32

These results are of interest in that they show that the removal of organic matter and color from water and the increase in nitrates are abnormally high in a filter which is allowed to rest but not to drain and have its pores fill with air. They also show that nitrification takes place most rapidly in the upper portion of the filter where the storage of organic matter is greatest. In this instance, also, just as in the case where the filter is drained, the abnormally high nitrates were washed out and disappeared in a few hours after placing the filter in operation.

It was thought that perhaps the organisms of nitrification might be in a more active state in intermittent than continuous filters and accordingly the continuous mate of Filter No. 3 B (Filter No. 8 A) was similarly treated, except that the period of rest was shorter. The gates on the inlet and outlet pipes of the latter filter were closed at 5 P.M. on May 16 and the filter allowed to rest, with the surface covered with water, until 5 A.M. on May 18, when the gates were opened to permit the water to pass through at a rate of 2,100,000 gallons per acre daily. Four samples were collected for analysis at somewhat different hours from those of Filter No. 3 B, owing to the difference in the rate of filtration. The results of analyses which are given in the next table show that if there was any difference in the activity of the nitrifying bacteria it was a slight one. Throughout the day the free oxygen in the effluent was about 85 per cent. of that necessary for saturation at the actual temperature (61° F.).

Continuous Filter No. 8 A,—May 18, 1894.

[Parts per 100,000.]

Hour.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates.	Nitrites.	
6.22 A.M.,	.20	.0010	.0092	.15	.0280	.0008	.24
10.01 A.M.,	.20	.0010	.0092	.15	.0480	.0000	.23
1.01 P.M.,	.19	.0016	.0120	.15	.1030	.0000	.27
4.06 P.M.,	.24	.0014	.0102	.15	.0300	.0000	.29

The nitrification by intermittent Filter No. 3 B was less complete during the winter of 1893–94 than in the case of its continuous mate, Filter No 8 A. It was suggested in the report of the Board for 1893 that this was probably due to the exposure of the surface layers where nitrification takes place to the largest extent, for from six to eight hours, to the freezing temperature of winter nights. During 1894 the method of operation of intermittent filters was changed so that the exposure was reduced to two hours during the milder temperature of day. The much more satisfactory nitrification in Filter No. 3 B during the early part of the winter of 1894–95 indicates that the theory noted above was correct.

Conclusions.

The evidence which has been accumulated on this subject indicates that intermittent filtration is successful in the chemical purification of all waters containing ordinary organic matter. Chemical purification by continuous filtration is successful only in the case of those waters which do not contain organic matter in excess of a certain limit determined by the relation of the organic matter to the free dissolved oxygen which is limited in quantity by the saturation point.

The Relation between Construction and Operation of Filters and the Quantity of Sand Scraped from the Surfaces to relieve Clogging.

The data which have been obtained in 1894, May to November inclusive, are summarized in the next table. The depths of sand removed were calculated in each case from the weight of the sand. These figures are presented as a matter of record and will not

be discussed, owing to the fact that the filters were subjected to abnormal treatments on numerous occasions for the purpose of experimentation.

It should be borne in mind that Filters Nos. 38, 42, 46, 48 and 49 received city (filtered) water until September 1.

Summary of Results of Scraping of Water Filters, May to November, 1894.

Number of Filter.	Method of Operation.	Effective Size. — Millimeter.	Average Rate — Gallons per Acre Daily.	Average Quantity Passed between Scrapings. — Gallons per Acre.	Average Depth of Sand Removed. — (Inches.)	Average Quantity Removed.	
						Cubic Yards per Acre.	Cubic Yards per Million Gallons of Water Filtered.
3 B, . .	Intermittent.	0.23	2,800,000	53,000,000	0.66	89	1.69
8 A, . .	Continuous.	0.23	2,500,000	65,000,000	0.52	69	1.23
18 A, . .	Intermittent.	0.48	4,900,000	208,000,000	1.05	138	0.68
33 A, . .	Continuous.	0.14	2,000,000	52,000,000	0.35	47	0.85
38, . .	Continuous.	0.20	2,600,000	50,000,000	0.30	40	0.77
41, . .	Intermittent.	0.14	2,000,000	33,000,000	0.34	46	1.31
42, . .	Continuous.	0.20	3,000,000	100,000,000	0.50	67	0.65
43, . .	Continuous.	0.26	4,800,000	103,000,000	0.68	91	0.84
44, . .	Continuous.	0.29	7,400,000	60,000,000	0.66	88	1.42
45, . .	Intermittent.	0.23	4,900,000	138,000,000	0.77	103	0.64
46, . .	Continuous.	0.29	2,300,000	55,000,000	0.38	51	0.90
47, . .	Intermittent.	0.29	6,400,000	44,000,000	0.72	96	2.10
48, . .	Continuous.	0.38	3,000,000	100,000,000	1.89	253	2.31
49, . .	Continuous.	0.38	5,600,000	127,000,000	0.49	66	0.51
50, . .	Continuous.	0.48	4,800,000	100,000,000	0.44	59	0.57

Unsatisfactory Features of the Method of Replacement of Clogged Sand with Clean Sand at the Time of Each Scraping.

The method of replacing with clean sand the clogged sand which was removed from the filters worked satisfactorily at first. After a time, however, it was found that the finer particles of the new and clean sand, together with some of the suspended matters of the unfiltered water, worked their way down to the junction of the old and new material. In several instances sub-surface clogging occurred in filters one or two days after scraping, and it was necessary to break up this layer before satisfactory results were obtained.

Such treatment as noted above interferes with bacterial efficiency. There are certain advantages associated with systematic replacement of material on each occasion; but all things considered it seems to be advisable to construct filters of such depth that they may be scraped for a year, perhaps, without replacement; then making a special point of carefully restoring the filter to its original depth and taking such steps as are necessary to prevent diminution in bacterial efficiency.

More Satisfactory Results from Covered Filters in a Climate such as exists at Lawrence.

From experience with the out-door experimental Filters, No. 3 B and 8 A, and the Lawrence city filter it appears that the difficulty in scraping the surface during the winter months is so great that it is advisable to provide water filters with covers in this climate. The difficulty arises from the removal of the ice which becomes two to three feet in thickness. Bacterial efficiency, however, is affected only in an indirect way through unequal rates of filtration caused by disturbance of the surface in places.

The Water taken from the Merrimack River and applied to the Experimental Filters.

With the exception of the city (filtered) water applied to Filters Nos. 38, 42, 46, 48 and 49 up to September 1, water has been taken from the Merrimack River and applied to all of the water filters. Up to July 20 the water was brought through a two-inch galvanized iron pipe, about 400 feet long, from the north canal of the Essex Company. On that date a somewhat shorter twelve-inch iron pipe was put into service to bring water from the forebay of the locks at the foot of this canal. A four-inch galvanized iron pipe is used for distribution of water in the station.

The water is substantially the same as the river water above Lawrence which is applied to the city filter. The turbidity and sediment are usually very slight, but after heavy rains and during the spring freshets become quite marked. Usually the odor is slight, but during cold weather, when the river is covered with ice, it becomes distinctly musty.

The results of analyses of the water as drawn at the station are given in the next two tables. In the first table are the average daily results of bacterial analyses. These results are the average of two analyses in all instances and frequently more have been made. Monthly averages of results of chemical analyses are presented in the second table beyond; with them are also the results of bacterial analyses of corresponding samples. Additional analyses in which are given the residue on evaporation and observations upon the odor, turbidity and microscopical organisms, appear in the earlier portion of this volume.

B. prodigiosus was applied in the river water to several of the filters during October, November and December. The degree of dilution of cultures in which this germ was applied was greater than during former years, and the amount of food matters introduced with the cultures was so small that the amount of organic matter added in this way to the water could scarcely be measured.

In the last annual report of the Board the results of analyses of the river water, especially the bacterial analyses, were presented quite completely for the months of January to April, inclusive, 1895.

Average Number of Bacteria per Cubic Centimeter by Days, in Canal Water (Merrimack River), 1894.

Day.	May.	June.	July.	August.	September.	October.	November.	December.
1, . . .	2,300	4,900	4,800	2,800	4,000	50,800	3,800	85,001
2, . . .	2,600	4,600	5,900	2,900	–	74,000	14,200	–
3, . . .	2,900	–	1,500	4,200	700	47,700	6,900	12,300
4, . . .	3,100	6,800	–	1,900	1,500	72,700	–	10,400
5, . . .	3,600	6,400	2,700	–	1,200	80,500	3,200	6,200
6, . . .	–	5,700	8,600	3,900	4,700	69,000	17,600	10,900
7, . . .	3,100	3,800	5,900	3,900	8,300	–	10,100	23,800
8, . . .	4,500	5,300	–	5,700	7,500	16,800	9,900	22,700
9, . . .	5,100	6,200	4,200	3,000	–	13,300	8,900	–
10, . . .	4,400	–	3,800	3,900	4,000	100,400	5,900	46,400
11, . . .	6,800	3,800	9,100	3,700	15,000	91,400	–	44,000
12, . . .	4,300	5,800	8,200	–	6,300	59,100	11,000	34,400
13, . . .	–	3,800	5,700	1,600	4,400	42,000	12,900	24,900
14, . . .	3,300	4,800	3,600	700	19,900	–	9,100	31,400
15, . . .	5,100	5,700	–	4,300	23,600	6,600	12,000	46,600
16, . . .	8,500	6,500	1,800	3,700	–	3,800	12,000	–
17, . . .	–	–	2,500	3,100	6,100	8,400	22,600	20,400
18, . . .	8,200	7,400	7,500	2,400	16,100	3,400	–	15,500
19, . . .	10,300	5,200	8,900	–	17,300	3,100	17,600	9,600
20, . . .	–	9,600	7,900	3,000	21,500	4,200	16,600	9,700
21, . . .	11,000	8,300	3,800	2,100	23,500	–	10,800	21,600
22, . . .	16,600	8,400	–	4,500	15,900	2,500	8,200	18,500
23, . . .	13,400	7,300	1,300	6,500	–	1,300	9,100	12,700
24, . . .	11,000	–	3,400	7,100	6,300	1,800	6,300	–
25, . . .	10,100	6,400	8,300	5,100	8,000	1,600	–	–
26, . . .	14,000	7,400	8,700	–	19,200	5,000	10,600	23,200
27, . . .	–	8,400	4,500	1,200	66,600	12,500	7,700	16,300
28, . . .	5,900	25,800	2,100	1,700	92,100	–	9,300	–
29, . . .	3,300	12,200	–	1,900	105,700	3,700	–	11,300
30, . . .	4,100	9,500	3,100	4,100	–	2,300	14,000	–
31, . . .	6,700	–	2,000	5,200	–	4,300	–	14,700

Monthly Averages of Analyses of Canal Water (Merrimack River).

[Parts per 100,000.]

1894.	Temperature. Deg. F.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.			Nitrates.	Nitrites.			
				Total.	Soluble.						
January, . . .	35	.43	.0055	.0164	.0141	.21	.015	.0001	.41	88	6,700
February, . . .	34	.40	.0068	.0160	.0148	.22	.018	.0001	.42	94	8,000
March, . . .	37	.47	.0040	.0193	.0172	.15	.013	.0001	.46	101	10,100
April, . . .	47	.43	.0027	.0143	.0125	.15	.014	.0000	.41	95	11,500
May, ...	57	.47	.0053	.0199	.0160	.16	.014	.0000	.46	86	7,300
June, ...	67	.52	.0063	.0200	.0163	.14	.011	.0000	.51	80	6,800
July, ...	77	.36	.0105	.0200	.0145	.19	.009	.0001	.32	69	7,000
August, . . .	74	.35	.0100	.0205	.0158	.30	.010	.0003	.26	52	3,600
September, . .	67	.31	.0074	.0176	.0141	.29	.011	.0001	.27	59	29,100
October, . . .	58	.41	.0094	.0189	.0166	.29	.017	.0002	.40	68	56,300
November, . .	44	.43	.0071	.0198	.0162	.25	.014	.0001	.47	88	8,300
December, . .	32	.38	.0099	.0223	.0186	.26	.018	.0001	.45	-	29,400

Detailed Account of the Work of the Several Water Filters in 1894.

The remaining portion of the report of the Lawrence investigations upon water filtration consists of a brief outline of the construction and operation of each filter, the average results of daily bacterial analyses, the monthly averages of chemical analyses and with them the average results of corresponding bacterial analyses. The daily bacterial results are made up by averaging, in the proper ratio, the results of several daily analyses in the case of the intermittent filters; several samples were collected for bacterial analysis from the effluents of continuous filters in many instances. This was not uniformly true during the latter part of the year, for the reason that there was very little variation in the numbers of bacteria found in these effluents. All filters were repeatedly subjected to several tests, especially at times when they were operated under abnormal conditions.

For the sake of understanding more thoroughly the process of water filtration all of these filters have been subjected purposely, at times, to treatments which are not necessarily a part of the process

and which should certainly be avoided in actual practice. The principal reason for the presentation of the daily bacterial results is to show that the average results from these experimental filters have been influenced in a large measure by a comparatively few poor results due to abnormal conditions and that the normal results are considerably better than would appear at first sight.

From Dec. 1, 1893, until the spring and early summer of 1894 the small in-door filters were allowed to rest, as has been described with considerable care above. The application of city (filtered) water to some of the filters during the summer, the methods of operating filters intermittently, the effect of deep scraping, and the influence of fluctuating rates of filtration are all important factors which have received considerable attention in the foregoing discussion. It only remains to record the dates on which these treatments took place in order that they may be studied together with the tables of daily bacterial results.

Application of B. Prodigiosus.

This germ has been applied to Filters Nos. 46, 48 and 49 with city (filtered) water during several weeks in July and August; to all of the in-door water Filters Nos. 18 A–50, inclusive, during October and November; and to Filter No. 8 A for a portion of the month of December. The general plan of the experiments has been the same as during previous years (see 1892 report of the Board, page 529), except that in some instances fewer *B. prodigiosus* have been applied at a time. A pure culture of this species of bacteria has been obtained by inoculation and growth for four days at 20° C. in a solution of one-tenth per cent. peptone and two-tenths per cent. glucose in city water. This mixture has been applied to the filters in some instances in the proportion of one part to three thousand parts of water, while in other cases the proportion has been one to thirty thousand parts of water, at intervals of one or two hours for ten hours a day and six days a week, according to the rate of filtration.

Numerous examinations of the effluents at frequent intervals have been made in order to learn whether or not this germ passed through the filters. The reasons why this species of bacteria has been used are that it is easy to differentiate from ordinary water bacteria and is apparently very similar to the Eberth germ of typhoid fever in

its mode of life in the river water. In the next table are given the average numbers of *B. prodigiosus* per cubic centimeter in the applied water for ten hours during each day that this germ was applied to the filters. Differences in degrees of dilution explain the marked differences in the numbers.

Average Number per Cubic Centimeter of Bacillus Prodigiosus in Applied River Water for Ten Hours Daily, 1894.

Day.	July.	August.	October.	November.	December.
1,	0	17,700	0	1,300	0
2,	0	16,300	2,600	3,200	0
3,	0	24,000	700	800	0
4,	0	10,700	5,300	0	0
5,	0	0	1,800	7,600	200
6,	8,300	16,900	3,800	3,600	200
7,	7,300	5,700	0	5,500	100
8,	0	13,700	1,600	5,600	260
9,	3,700	13,500	2,700	5,500	–
10,	11,300	4,700	2,900	4,700	300
11,	10,000	13,300	2,800	0	375
12,	10,700	0	3,700	2,500	700
13,	14,000	4,000	5,300	4,700	375
14,	11,000	8,000	0	9,100	–
15,	0	5,300	5,100	6,600	205
16,	19,700	27,700	1,900	6,600	0
17,	21,700	8,300	1,700	6,600	0
18,	11,300	4,000	5,000	0	0
19,	12,000	0	4,800	5,400	0
20,	11,000	0	7,500	4,600	0
21,	18,700	0	0	5,100	0
22,	0	0	11,700	4,800	0
23,	10,700	0	6,300	6,200	0
24,	12,700	0	2,800	4,200	0
25,	19,000	0	2,700	0	0
26,	12,000	0	2,800	3,800	0
27,	10,000	0	8,000	5,200	0
28,	21,300	0	0	2,800	0
29,	–	0	4,300	0	0
30,	9,000	0	2,900	5,000	0
31,	16,700	0	800	–	0

Filter No. 3 B.

This intermittent filter was started Sept. 23, 1893, and has contained 60 inches in depth of sand of an effective size of 0.23 millimeter. In the report of the Board for 1893, page 510, an account will be found of the construction and results of operation of this filter up to May 1, 1894.

The principal features in the history of this filter during the past year are the change in the method of intermittent operation by which the period of rest became two hours during the day instead of eight hours at night after June 6; the permanent increase in the rate of filtration on July 20 from 2,000,000 to 5,000,000 gallons per acre daily; and the arrangement of the trap, on September 6, to keep the lower foot of material from draining. On July 19 a trap was attached to the outlet, but so that the level of the point of discharge was not changed. On Sundays the filter has been operated continuously. With the exception of Sundays several samples have been taken daily for bacterial analysis and it is an average of their several results which appear in the next table. The only exception to the above statement has occurred when the filter was not running. This happened from May 14–18, and for shorter times on other occasions, when special experiments were in progress. Again in August the operation was interfered with for several days, owing to repairs which were made. In the period from May 14–18 the surface remained covered with water but it was uncovered August 20–23.

Statements of the results of treatment to relieve clogging from the surface accumulation of sediment and organic matter are presented for reference in connection with the bacterial results. A summary of these results and corresponding results for all of the water filters has been given above. During the earlier part of the year the filter was filled from below with city (filtered) water after scraping, as was noted in the last report. In most instances during the remainder of the year the river water has been applied as usual from the top just after scraping.

The record of the dates on which the surface has been scraped, since May 1, together with the depth of clogged sand removed, is as follows: June 4, 0.4 inch; June 22, 0.2 inch; July 11, 0.15 inch; July 25, 0.2 inch; August 4, 0.4 inch; September 21, 1.0 inch; October 3, 1.0 inch; October 18, 1.0 inch; November 3, 1.0 inch; November 13, 1.0 inch, and November 26, 1.0 inch. After scraping

it has been the general custom to loosen the old sand to a depth of about one inch and to level the surface. During the first half of the year new sand was added to replace that scraped off; but this practice was abandoned during the latter part of the summer.

The surface was raked to a depth of one inch to relieve clogging without scraping, on the following dates: August 31, September 12 and 27, October 2, 9, 12, 17, 25 and 31, November 2, 10, 17, 20 and 24, December 6, 12 and 17.

On November 28 the surface was spaded over to a depth of 6 inches for the purpose of investigation. This treatment was necessary in order to continue the operation of the filter according to the regular method.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 3 B, 1894.

Day.	May.	June.	July.	August.	September.	October.	November.	December.
1, . . .	49	75	57	52	24	21	8	735
2, . . .	40	38	50	30	-	11	8	-
3, . . .	40	-	35	14	-	120	8	569
4, . . .	43	278	-	34	46	387	-	346
5, . . .	45	130	32	-	23	84	16	339
6, . . .	-	74	33	-	23	31	23	452
7, . . .	65	60	34	90	16	-	40	506
8, . . .	71	44	-	61	188	17	126	264
9, . . .	53	38	26	49	-	12	205	-
10, . . .	62	-	23	70	15	23	110	262
11, . . .	43	48	328	156	69	86	-	462
12, . . .	50	60	150	-	32	-	102	325
13, . . .	-	44	82	57	78	236	438	227
14, . . .	77	38	43	30	24	-	320	205
15, . . .	-	26	-	20	25	150	450	175
16, . . .	-	37	52	22	-	94	201	-
17, . . .	-	-	44	-	18	65	96	147
18, . . .	105	38	52	-	24	33	-	352
19, . . .	73	32	42	-	15	27	165	75
20, . . .	-	31	63	-	12	30	123	78
21, . . .	110	49	732	-	22	-	62	55
22, . . .	88	76	-	-	39	6	29	37
23, . . .	81	154	543	250	-	5	32	52
24, . . .	48	-	378	165	26	5	17	66
25, . . .	46	123	80	30	99	4	-	-
26, . . .	56	71	114	-	14	7	240	27
27, . . .	-	49	61	21	10	10	172	48
28, . . .	137	49	60	36	16	-	565	-
29, . . .	71	36	-	20	21	7	-	64
30, . . .	133	27	35	15	-	7	1,300	-
31, . . .	66	-	34	23	-	8	-	62

Monthly Averages of Analyses of Effluent of Filter No. 3 B.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
January, . .	1,560,000	35	33	.38	.0021	.0117	.21	.025	.0000	.35	106	194
February, . .	1,455,000	34	33	.34	.0018	.0107	.22	.027	.0000	.36	102	197
March, . .	1,482,000	37	37	.40	.0014	.0095	.15	.018	.0000	.35	103	165
April, . . .	1,361,000	47	48	.35	.0011	.0090	.15	.020	.0000	.33	101	83
May, . . .	1,381,000	57	58	.34	.0012	.0103	.17	.032	.0000	.33	96	70
June, . . .	2,016,000	67	67	.34	.0008	.0099	.14	.031	.0000	.36	80	73
July, . . .	2,759,000	77	74	.17	.0007	.0065	.20	.033	.0000	.19	80	49
August, . .	2,621,000	74	74	.12	.0004	.0057	.30	.052	.0000	.13	70	17
September, . .	3,384,000	67	67	.15	.0004	.0063	.28	.037	.0000	.19	65	27
October, . .	4,002,000	58	58	.18	.0007	.0081	.32	.038	.0000	.21	45	28
November, . .	3,819,000	44	44	.30	.0027	.0082	.26	.030	.0000	.33	84	107
December, . .	3,572,000	32	33	.30	.0112	.0104	.26	.021	.0000	.34	–	26

Filter No. 7 A.

In July sewage Filter No. 7 (sub-surface application) was dug out and after washing the under-drains with city water, 2 feet of sand of an effective size of 0.26 millimeter were placed in the tank. City water was applied from below on the night of July 20 and after the surface was covered river water was applied and has been filtered continuously at the rate of 2,000,000 gallons per acre daily. On September 6 the outlet was trapped so as to prevent the lower foot of sand from draining at times when the filter was allowed to uncover to treat the surface.

The surface was raked and not scraped to relieve clogging. It was raked on September 19, October 25, November 27 and December 23. After raking on the last date the numbers of bacteria in the effluent were unusually high in spite of the fact that the filter was filled with city water from below and allowed to rest over night. The diminution in efficiency appears to have been caused by frost at the surface.

In August the filter was out of service for several days. From August 17–23 the filter was allowed to rest with its surface covered with water.

Average Daily Numbers of Bacteria per Cubic Centimeter in Effluent of Filter No. 7 A, 1894.

Day.	July.	August.	September.	October.	November.	December.
1,	–	13	43	45	30	340
2,	–	16	–	50	22	–
3,	–	30	–	42	13	378
4,	–	9	52	50	–	225
5,	–	–	8	60	26	210
6,	–	–	7	27	41	280
7,	–	268	60	–	34	164
8,	–	63	260	40	110	107
9,	–	96	–	22	250	–
10,	–	170	–	44	127	180
11,	–	72	114	61	–	308
12,	–	–	15	54	105	163
13,	–	586	30	46	95	191
14,	–	546	16	–	60	128
15,	–	310	24	46	52	200
16,	–	270	–	45	41	–
17,	–	–	15	30	23	149
18,	–	–	280	19	–	83
19,	–	–	210	19	32	23
20,	–	–	95	18	30	23
21,	9,200	–	260	–	48	29
22,	–	–	54	8	20	26
23,	3,200	860	–	15	18	–
24,	1,300	148	35	22	22	2,660
25,	100	38	73	30	–	–
26,	200	–	25	29	33	455
27,	600	120	42	26	5,500	560
28,	–	94	37	–	450	–
29,	–	75	26	29	–	–
30,	700	71	–	17	650	–
31,	130	57	–	24	–	–

Monthly Averages of Analyses of Effluent of Filter No. 7 A.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
August, . .	1,160,000	74	78	.19	.0005	.0092	.26	.015	.0000	.20	31	20
September, .	1,538,000	67	67	.14	.0004	.0068	.30	.033	.0002	.19	28	65
October, . .	1,969,000	58	57	.20	.0002	.0090	.32	.037	.0000	.22	24	36
November, . .	1,767,000	44	42	.31	.0013	.0101	.26	.024	.0000	.36	62	99
December, . .	2,189,000	32	32	.30	.0130	.0118	.26	.021	.0001	.35	–	283

Filter No. 8 A.

This continuous filter 17.3 feet in diameter was started Sept. 26, 1893, and like Filter No. 3 B has contained 60 inches in depth of sand of an effective size such as is found in a portion of the Lawrence city filter. In the last report of the Board, page 511, an account will be found of the results of operation up to May 1, 1894, and a comparison of its efficiency with that of its intermittent mate, Filter No. 3 B.

On July 19 a trap was attached to the outlet but so that the level of the point of discharge was not changed. The trap was raised on September 6 so that the lower foot of material could not be drained. The rate of filtration was 2,000,000 gallons per acre daily up to July 20 when it was permanently increased to 5,000,000 gallons. On June 25 and 26 the filter was operated intermittently, but on all other occasions the surface has never been allowed to uncover except for scraping or raking to relieve clogging.

B. prodigiosus was applied from December 5–15 and the most searching tests available failed to reveal the presence of this germ in the effluent. The number of applied bacteria of this species, however, was smaller than has been the case usually.

The dates and depths of surface scraping to relieve clogging are as follows: June 2, 0.5 inch; June 22, 0 2 inch; July 11, 0.2 inch; July 24, 0.25 inch; August 2, 0.2 inch; August 16, 0.3 inch; October 12, 1.0 inch; October 26, 1.0 inch; November 15,

1.0 inch; and December 24, 1.0 inch. From May to November the filter was filled with river water from the top after scraping; during the rest of the year it was the custom, as a rule, to fill with city (filtered) water from below. It appears that frost interfered with bacterial efficiency at the time of scraping on December 24. New sand was put on filter to replace clogged sand at the time of its removal up to September 1, after which date the practice was abandoned. After scraping the surface of the old sand has been raked to a depth of about one inch to loosen and level it.

Surface clogging has also been removed by raking, without scraping, to a depth of one inch on September 7, 21 and 28, October 5, 25, November 8, 13, 26 and December 6.

From August 7 to 11 the rate of filtration was reduced from 5,000,000 to 1,000,000 gallons per acre daily, owing to an insufficient supply of water. On August 16 the filter was stopped with the surface covered with water; the water was allowed to drain out on August 20 and the filter put in service on August 23.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 8 A.

Day.	1894.								
	May.	June.	July.	August.	September.	October.	November.	December.	
								Water Bacteria.	B. Prodigiosus.
1, . .	25	23	10	19	2	11	11	–	–
2, . .	26	16	14	–	–	11	11	–	–
3, . .	26	–	11	14	–	4	1	336	–
4, . .	31	83	–	–	16	4	–	156	–
5, . .	27	71	15	–	14	5	2	91	0
6, . .	–	37	11	40	4	2	3	100	0
7, . .	28	22	27	32	9	–	–	483	0
8, . .	21	30	–	13	43	5	90	677	0
9, . .	22	21	8	15	–	3	171	–	–
10, . .	27	–	10	7	110	3	190	462	0
11, . .	37	47	45	35	44	–	–	525	0
12, . .	20	29	16	–	19	370	–	406	0
13, . .	–	21	9	6	28	280	340	138	0
14, . .	26	38	6	7	11	–	98	873	0
15, . .	34	37	–	15	3	102	102	744	0
16, . .	27	17	8	30	–	13	406	–	–
17, . .	–	–	15	–	1	9	560	138	0
18, . .	23	21	9	–	14	5	–	101	0
19, . .	30	18	12	–	66	2	150	40	0
20, . .	–	20	53	14	3	3	140	162	0
21, . .	31	12	1,281	–	[illegible]	1	41	130	0
22, . .	28	49	–	–	10	1	17	99	0
23, . .	23	50	978	96	–	5	22	87	0
24, . .	23	–	1,800	65	15	9	12	25	0
25, . .	29	65	192	26	4	13	–	–	–
26, . .	28	75	158	–	10	16	65	229	0
27, . .	–	59	27	11	14	18	26	423	0
28, . .	33	48	14	5	6	–	295	280	0
29, . .	–	21	–	5	7	10	–	52	0
30, . .	–	11	6	3	–	6	620	–	0
31, . .	58	–	–	3	–	9	–	20	0

Monthly Averages of Analyses of Effluent of Filter No. 8 A.

[Parts per 100,000.]

1894.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Deg. F. Applied Water.	Temperature. Deg. F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
January,	1,752,000	35	33	.37	.0016	.0115	.21	.030	.0000	.35	88	72
February,	1,502,000	34	33	.32	.0017	.0106	.22	.031	.0000	.33	89	62
March,	1,320,000	37	39	.39	.0016	.0102	.16	.018	.0000	.34	93	71
April,	1,326,000	47	47	.32	.0014	.0087	.25	.021	.0000	.31	85	37
May,	1,591,000	57	60	.30	.0010	.0096	.16	.032	.0000	.29	70	33
June,	1,645,000	67	68	.31	.0009	.0093	.14	.024	.0000	.32	77	41
July,	2,654,000	77	74	.16	.0008	.0064	.20	.025	.0000	.18	37	10
August,	2,764,000	74	76	.14	.0004	.0061	.29	.039	.0000	.15	31	11
September,	4,167,000	67	70	.16	.0002	.0060	.30	.025	.0002	.20	41	51
October,	4,623,000	58	58	.18	.0004	.0068	.32	.042	.0000	.20	26	1
November,	3,812,000	44	43	.31	.0034	.0106	.26	.020	.0000	.37	70	68
December,	3,580,000	32	33	.30	.0092	.0119	.26	.018	.0000	.36	-	542

Filter No. 18 A.

This intermittent filter, 20 inches in diameter, was started Sept. 17, 1889, and has contained sand of an effective size of 0.48 millimeter. During the latter part of 1893 the filter was restored to its original depth of 62 inches. In the last report of the Board, page 496, a summary will be found of the method of operation during its several years of service. It has always been operated intermittently, although the procedure has varied within wide limits.

From Dec. 8, 1893, to July 22, 1894, this filter was drained and allowed to rest. On July 22 river water was applied from the top until the surface was covered. Filtration was begun on July 23, at a rate of 5,000,000 gallons per acre daily. The method of allowing atmospheric air to reach the pores of the material was the same as in the case of intermittent Filter No. 3 B after June 6; that is, the surface was allowed to remain uncovered for two hours during the forenoon. On September 1 the trap was raised to prevent lower foot of material from draining.

The surface was scraped to relieve clogging on the following dates: September 1, 0.34 inch; October 13, 1.43 inches; and November 27, 1.43 inches. New sand was put in the filter only on the occasion of the first scraping. Raking to a depth of 1 inch to relieve clogging was resorted to September 12, October 11 and 17, November 15, 24 and 28.

This filter, with all other twenty-inch in-door filters, accounts of which follow, went out of service on December 1, when chemical and bacterial analyses of the filtering materials were made, with results presented on page 601.

During the last two months of operation of these smaller experimental filters, Nos. 18 A–50, *B. prodigiosus* was applied to the river water which was filtered by them. These results are recorded side by side with the ordinary water bacteria in the case of each filter, and further comment on them appears to be unnecessary at this time.

All of these filters mentioned above, furthermore, have been filled with river water from the top after scraping and put in operation at once.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 18 A.

Day.	1894.						
	July.	August.	September.	October.		November.	
				Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1,	–	50	114	190	–	39	0
2,	–	57	–	368	5	42	0
3,	–	46	–	250	2	43	0
4,	–	47	18	461	1	–	–
5,	–	–	19	458	1	96	1
6,	–	116	26	617	11	155	3
7,	–	95	34	–	–	144	2
8,	–	92	204	648	6	184	4
9,	–	57	–	154	1	162	2
10,	–	58	29	178	2	168	3
11,	–	41	70	290	0	–	–
12,	–	–	72	840	1	–	–
13,	–	36	240	2,750	23	185	3
14,	–	22	148	–	–	89	2
15,	–	49	404	–	–	140	4
16,	–	84	–	104	8	69	0
17,	–	153	66	186	2	37	1
18,	–	160	102	179	2	–	–
19,	–	–	121	150	1	38	1
20,	–	150	86	132	1	25	0
21,	–	128	75	–	–	103	0
22,	–	113	95	60	0	32	0
23,	13,500	148	–	50	0	25	0
24,	1,700	100	140	53	0	20	0
25,	1,100	81	50	55	1	–	–
26,	350	–	131	70	0	30	0
27,	325	55	342	76	2	26	0
28,	65	74	381	–	–	118	1
29,	–	58	297	46	0	–	–
30,	98	176	–	61	0	450	2
31,	15	68	–	53	0	–	–

Monthly Averages of Analyses of Effluent of Filter No. 18 A.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
July, ...	5,060,000	77	81	.25	.0052	.0134	.20	.026	.0002	.27	37	200
August, . .	5,020,000	74	72	.18	.0008	.0075	.30	.026	.0000	.17	42	65
September, . .	5,140,000	67	68	.18	.0005	.0068	.29	.033	.0000	.18	60	288
October, . .	4,720,000	58	55	.25	.0005	.0085	.28	.034	.0000	.31	51	259
November, . .	4,600,000	44	39	.33	.0047	.0109	.26	.022	.0000	.37	83	139

Filter No. 33 A.

This continuous filter was started April 28, 1892, and has contained sand of an effective size of 0.14 millimeter. The original depth was 60 inches, and this was the actual depth at the beginning of the past year. From Dec. 8, 1893, to July 22, 1894, the filter was drained and out of service. On July 22 the filter received river water until the surface was covered, and July 23 continuous filtration was begun at a rate of 2,000,000 gallons per acre daily. The trap on the outlet pipe was raised on September 1 so that the lower foot of material could not be drained.

The dates and depths of scraping to relieve clogging are as follows: September 17, 0.28 inch; October 15, 0.36 inch; November 1, 0.31 inch; November 15, 0.29 inch; and November 28, 0.48 inch.

The rate of filtration was purposely fluctuated on October 17, 23 and 30. On November 7 the gate on the outlet was opened wide to allow rate of filtration to reach the maximum for about four hours.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 33 A.

Day.	1894.						
	July.	August.	September.	October.		November.	
				Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1,	-	21	6	19	0	14	0
2,	-	34	-	462	25	8	0
3,	-	9	-	469	3	9	0
4,	-	49	24	680	25	-	-
5,	-	-	7	350	6	12	0
6,	-	46	15	149	3	15	1
7,	-	40	85	-	-	8	0
8,	-	23	21	130	10	40	1
9,	-	18	-	58	3	93	0
10,	-	15	-	97	5	42	2
11,	-	10	90	542	8	-	-
12,	-	-	23	360	5	56	1
13,	-	11	-	178	2	48	3
14,	-	18	53	-	-	70	4
15,	-	12	130	127	1	81	2
16,	-	10	-	35	2	36	1
17,	-	18	90	26	1	20	0
18,	-	26	30	20	1	-	-
19,	-	-	20	16	0	16	0
20,	9,700	11	15	11	0	16	1
21,	1,300	8	12	-	-	35	1
22,	-	9	8	6	0	10	0
23,	800	14	-	8	0	12	0
24,	600	18	23	11	0	15	0
25,	300	13	14	4	0	-	-
26,	400	-	9	27	0	17	0
27,	800	8	9	20	0	38	0
28,	10	13	9	-	-	85	2
29,	-	14	12	11	0	-	-
30,	170	15	-	6	1	188	1
31,	10	25	-	14	0	-	-

Monthly Averages of Analyses of Effluent of Filter No. 33 A.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
July, . . .	2,340,000	77	77	.19	.0006	.0068	.21	.027	.0012	.21	4	300
August, . .	1,920,000	74	71	.16	.0007	.0069	.30	.025	.0004	.16	7	7
September, . .	1,860,000	67	65	.14	.0020	.0070	.30	.022	.0003	.18	31	51
October, . .	1,960,000	58	54	.23	.0005	.0081	.28	.031	.0000	.30	42	160
November, . .	2,040,000	44	47	.26	.0015	.0089	.27	.026	.0000	.30	76	7

Filter No. 38.

This continuous filter was started April 28, 1892, and has contained sand of an effective size of 0.20 millimeter. At the beginning of the year the depth was 20 inches. From Dec. 8, 1893, to May 19, 1894, the filter was drained and out of service. On the latter date the filter was filled with city (filtered) water from below. The continuous filtration of the city water (double filtration of the Merrimack River water) was begun on May 21, at a rate of 2,000,000 gallons per acre daily. The rate of filtration increased on July 20 to 3,000,000 gallons per acre daily. Application of city water ceased September 1, and after that date ordinary river water was applied. On this date also the trap on the outlet pipe was raised to prevent the lower foot of material from being drained.

The dates and depths of scraping are as follows: July 17, 0.20 inch; September 3, 0.23 inch; September 25, 0.21 inch; October 8, 0.19 inch; October 20, 0.25 inch; October 26, 0.50 inch; November 2, 0.32 inch; November 12, 0.32 inch; November 19, 0.41 inch; and November 26, 0.39 inch. On the first four occasions new sand was added to replace that removed by scraping.

The rate of filtration was fluctuated on October 23, November 5 and 9.

The number of bacteria in the applied city (filtered) water will be found in a table beyond.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 38.

Day.	1894.								
	May.	June.	July.	August.	September.	October.		November.	
						Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . . .	-	184	26	8	16	20	-	6	0
2, . . .	-	173	33	46	-	20	-	10	1
3, . . .	-	-	23	-	5	41	-	14	1
4, . . .	-	195	-	6	8	31	-	-	-
5, . . .	-	202	26	-	12	32	-	52	6
6, . . .	-	153	60	22	10	50	-	70	1
7, . . .	-	50	45	11	13	-	-	76	0
8, . . .	-	43	-	11	14	34	-	93	0
9, . . .	-	112	40	4	-	19	2	107	0
10, . . .	-	-	75	8	11	50	1	86	0
11, . . .	-	65	45	21	-	63	0	-	-
12, . . .	-	124	21	-	36	47	1	-	-
13, . . .	-	24	18	7	11	30	2	158	12
14, . . .	-	62	14	8	8	-	-	178	15
15, . . .	-	20	-	5	20	25	1	138	9
16, . . .	-	38	20	15	-	22	0	72	1
17, . . .	-	-	47	10	10	14	0	60	2
18, . . .	-	38	54	85	6	11	0	-	-
19, . . .	-	20	49	-	20	3	0	50	1
20, . . .	-	26	35	7	4	8	0	97	0
21, . . .	132,000	-	10	5	10	-	-	70	2
22, . . .	22,500	18	-	13	10	1	0	63	3
23, . . .	6,000	30	10	21	-	8	0	40	1
24, . . .	2,000	-	6	7	13	5	0	20	0
25, . . .	2,400	36	5	6	14	1	0	-	-
26, . . .	600	46	10	-	29	20	1	43	1
27, . . .	-	20	14	8	57	44	2	28	0
28, . . .	358	14	15	3	45	-	-	50	0
29, . . .	365	54	-	4	12	25	0	-	-
30, . . .	134	26	9	3	-	15	0	119	0
31, . . .	189	-	9	4	-	11	0	-	-

Monthly Averages of Analyses of Effluent of Filter No. 38.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
May, . . .	1,980,000	57	53	.20	.0008	.0080	.23	.049	.0000	.21	-	18
June, . . .	2,000,000	67	61	.23	.0010	.0081	.19	.040	.0000	.23	53	91
July, . . .	2,300,000	77	69	.15	.0011	.0075	.22	.037	.0000	.15	40	48
August, . .	3,040,000	74	70	.09	.0008	.0054	.29	.036	.0000	.11	43	13
September, . .	2,880,000	67	65	.07	.0004	.0051	.33	.029	.0000	.12	44	13
October, . .	2,960,000	58	57	.14	.0005	.0079	.29	.033	.0000	.26	36	18
November, . .	2,860,000	44	41	.33	.0016	.0110	.24	.020	.0000	.38	78	89

Filter No. 41.

This intermittent filter, a duplicate of continuous Filter No. 33 A, was started May 9, 1892, and has contained sand of an effective size of 0.14 millimeter. The method of intermittent operation has been the same as for all other intermittent filters, namely, a period of two hours for the surface to be uncovered.

From Dec. 8, 1893, to July 20, the filter was drained and out of service. On the latter date river water from the canal was applied to the filter from the top, and filtration was begun at a rate of 2,000,000 gallons per acre per day. The trap was raised September 1, to prevent the lower foot of material from draining. It is doubtful whether this makes any difference whatever in this case, as the material is so fine that there is a saturated layer of considerable depth due to capillarity.

The dates and depths of scraping to relieve clogging are as follows: September 14, 0.33 inch; October 2, 0.28 inch; October 17, 0.25 inch; October 25, 0.41 inch; November 1, 0 30 inch; November 12, 0.39 inch; November 17, 0.43 inch; and November 24, 0.31 inch. New sand was added to replace the clogged material on the first two occasions.

Average Number of Bacteria per Cubic Centimeter Daily in Effluent of Filter No. 41.

Day.	1894.						
	July.	August.	Sept.	October.		November.	
				Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, ...	-	18	4	13	-	8	0
2, ...	-	32	-	31	0	22	0
3, ...	-	15	-	96	0	9	0
4, ...	-	8	5	28	0	-	-
5, ...	-	-	10	9	1	12	0
6, ...	-	39	7	10	0	9	0
7, ...	-	14	11	-	-	11	0
8, ...	-	18	4	42	0	8	0
9, ...	-	18	-	14	0	18	0
10, ...	-	12	21	7	0	14	0
11, ...	-	15	22	145	0	-	-
12, ...	-	-	11	88	1	40	0
13, ...	-	15	11	77	1	75	1
14, ...	-	14	23	-	-	85	0
15, ...	-	5	31	24	0	94	0
16, ...	-	16	-	21	0	24	0
17, ...	-	9	15	18	0	124	0
18, ...	-	12	9	15	0	-	-
19, ...	-	-	16	12	0	170	0
20, ...	5,500	7	6	10	0	72	0
21, ...	1,800	5	11	-	-	66	1
22, ...	-	4	13	7	0	24	0
23, ...	400	7	-	6	0	30	1
24, ...	500	4	13	5	0	28	0
25, ...	500	3	19	3	0	-	-
26, ...	250	-	29	21	0	210	0
27, ...	200	3	22	17	0	85	0
28, ...	45	18	48	-	-	48	0
29, ...	-	7	32	14	0	-	-
30, ...	93	5	-	13	0	180	0
31, ...	15	3	-	11	0	-	-

Monthly Averages of Analyses of Effluent of Filter No. 41.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid		Nitrates.	Nitrites.			
July,	2,460,000	77	78	.19	.0006	.0082	.20	.028	.0000	.22	51	400
August,	2,300,000	74	72	.16	.0005	.0060	.31	.029	.0000	.15	63	9
September,	2,040,000	67	66	.11	.0004	.0055	.32	.029	.0000	.15	59	17
October,	1,920,000	58	54	.24	.0005	.0083	.28	.032	.0001	.27	77	64
November,	1,760,000	44	42	.27	.0024	.0100	.25	.022	.0000	.33	86	15

Filter No. 42.

This continuous filter was started Oct. 29, 1892, and has contained sand of an effective size of 0.20 millimeter. The depth has been less than 10 inches.

From Dec. 8, 1893, to April 6, 1894, the filter was drained and out of service. Several times during April this filter was used in the study of special points, and it was not until the early part of May that city (filtered) water was regularly applied and tested. The operation was continuous and the rate of filtration was 3,000,000 gallons per acre daily.

River water was applied beginning September 1, when the trap was raised to a height of 1 foot above the top of the under-drain.

The dates and depths of scraping are as follows: May 29, 0.25 inch; July 5, 0.19 inch; July 31, 0.21 inch; September 3, 0.19 inch; September 18, 0.19 inch; November 10, 1.09 inches; and November 28, 1.38 inches. New sand was put in to replace clogged material on the first two occasions.

Clogging at the surface was removed by raking to a depth of 1 inch on the following dates: September 29, October 11, 24 and 29, November 3, 8, 13, 19, 23 and 26.

The rate of filtration was fluctuated October 19, 23 and 26.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 42.

Day.	1894.								
	May.	June.	July.	August.	Sept.	October.		November.	
						Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . .	-	525	30	23	3	5	-	13	0
2, . .	-	608	37	17	-	6	-	18	0
3, . .	-	-	28	12	-	6	-	14	0
4, . .	-	205	-	14	12	5	-	-	-
5, . .	3,670	278	30	-	13	3	-	48	1
6, . .	-	98	25	25	14	3	-	104	2
7, . .	140	65	18	7	9	-	-	180	3
8, . .	150	106	-	6	312	50	-	320	10
9, . .	80	94	17	4	-	22	0	270	7
10, . .	225	-	25	5	-	124	1	488	10
11, . .	-	52	15	9	-	705	10	-	-
12, . .	-	44	15	-	11	120	0	330	6
13, . .	-	47	19	17	23	132	1	370	9
14, . .	160	42	25	8	21	-	-	680	30
15, . .	218	20	-	4	31	87	0	339	10
16, . .	212	30	19	10	-	50	0	210	4
17, . .	131	-	19	7	18	35	0	110	6
18, . .	-	23	25	8	47	20	0	-	-
19, . .	180	29	21	-	23	15	0	210	4
20, . .	-	19	11	10	27	16	0	115	2
21, . .	170	46	16	3	21	-	-	44	2
22, . .	258	22	-	8	20	9	0	44	3
23, . .	155	43	15	5	-	14	0	210	17
24, . .	212	-	14	3	18	19	0	70	0
25, . .	290	46	5	8	10	24	0	-	-
26, . .	316	30	20	-	18	49	0	380	5
27, . .	-	28	12	3	30	45	5	49	1
28, . .	333	21	14	5	27	-	-	220	0
29, . .	430	28	-	12	260	138	0	-	-
30, . .	298	46	12	2	-	35	0	305	1
31, . .	390	-	24	3	-	24	0	-	-

Monthly Averages of Analyses of Effluent of Filter No. 42.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F. Applied Water.	Temperature. Deg. F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
April, . . .	3,220,000	47	42	.11	.0030	.0060	.22	.043	.0005	.12	97	3,700
May, . . .	3,000,000	57	54	.18	.0010	.0077	.20	.041	.0000	.21	77	145
June, . . .	3,040,000	67	60	.23	.0010	.0078	.19	.036	.0000	.22	58	90
July, . . .	3,000,000	77	69	.15	.0014	.0079	.22	.036	.0000	.17	47	33
August, . .	3,040,000	74	71	.09	.0010	.0059	.30	.036	.0000	.11	49	19
September, .	2,900,000	67	66	.08	.0004	.0060	.34	.030	.0000	.13	45	16
October, . .	3,000,000	58	56	.23	.0007	.0089	.29	.034	.0000	.29	50	50
November, . .	2,880,000	44	41	.33	.0040	.0120	.24	.019	.0000	.41	73	165

Filter No. 43.

This continuous filter was started May 20, 1893, and has contained sand of an effective size of 0.26 millimeter. The depth at the beginning of the year was 60 inches.

This filter was out of service from Dec. 8, 1893, to July 19, 1894, when it was filled from the top with river water. Continuous filtration of the river water was begun and continued at a rate of 5,000,000 gallons per acre daily. On September 1, the trap was raised to a height of 12 inches above the top of the under-drains.

The dates and depths of scraping of the surface are as follows: August 7, 0.39 inch; August 27, 0.27 inch; September 5, 0.31 inch; September 12, 0.24 inch; October 13, 1.46 inches; and Novembei 24, 1.42 inches. New sand was put back into the filter on the first four occasions.

Raking to a depth of 1 inch to relieve clogging occurred on September 25, October 4, 12 and 22, November 12, 17, 22 and 26.

The rate of filtration was fluctuated on October 17 and 23 and November 9.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 43.

Day.	1894.						
	July.	August.	September.	October.		November.	
				Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . . .	-	30	64	70	-	60	0
2, . . .	-	17	-	74	0	51	0
3, . . .	-	17	-	102	0	42	0
4, . . .	-	12	37	60	0	-	-
5, . . .	-	-	22	245	0	86	2
6, . . .	-	238	50	-	-	135	6
7, . . .	-	190	33	728	11	145	5
8, . . .	-	100	35	273	4	152	5
9, . . .	-	34	-	196	3	135	2
10, . . .	-	33	-	1,274	11	-	-
11, . . .	-	22	120	1,134	4	-	-
12, . . .	-	-	140	2,000	40	-	-
13, . . .	-	15	80	3,640	78	211	7
14, . . .	-	20	180	-	-	45	2
15, . . .	-	12	208	-	-	110	5
16, . . .	-	350	-	280	0	79	0
17, . . .	-	18	44	216	0	319	5
18, . . .	-	17	63	151	1	-	-
19, . . .	23,000	-	73	204	4	32	1
20, . . .	5,900	22	100	150	3	34	0
21, . . .	3,400	24	85	-	-	31	1
22, . . .	-	23	48	130	0	340	8
23, . . .	700	32	-	67	0	60	7
24, . . .	1,500	17	76	104	1	68	1
25, . . .	-	17	144	61	1	-	-
26, . . .	800	-	182	65	0	270	6
27, . . .	100	21	241	57	0	141	3
28, . . .	31	10	235	-	-	130	1
29, . . .	-	21	230	34	0	-	-
30, . . .	30	5	-	22	1	580	3
31, . . .	42	22	-	52	0	-	-

Monthly Averages of Analyses of Effluent of Filter No. 43.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid		Nitrates.	Nitrites.			
July,	5,000,000	77	81	.26	.0030	.0120	.20	.045	.0008	.27	15	1,450
August,	4,800,000	74	74	.15	.0004	.0076	.30	.026	.0001	.17	15	30
September,	4,600,000	67	71	.13	.0004	.0062	.30	.030	.0001	.19	4	75
October,	4,680,000	58	58	.28	.0007	.0102	.26	.029	.0000	.37	42	155
November,	4,880,000	44	41	.40	.0014	.0112	.28	.026	.0000	.43	71	80

Filter No. 44.

This continuous filter was started May 20, 1893, and has contained sand of an effective size of 0.29 millimeter. At the beginning of the year the depth was 60 inches.

From Dec. 8, 1893, to July 19, 1894, this filter was out of service. Beginning on the latter date this filter received river water continuously at a rate of 7,500,000 gallons per acre daily. On September 1, the trap on the outlet was raised to a height of 1 foot above the top of the under-drains.

The dates and depths of scraping are as follows: August 7, 0.32 inch; August 21, 0.26 inch; August 25, 0.21 inch; September 12, 0.12 inch; September 22, 0.26 inch; September 25, 0.85 inch; October 2, 1.48 inches; October 12, 0.50 inch; October 13, 2.63 inches; October 25, 0.52 inch; November 1, 0.43 inch; November 10, 0.47 inch; November 14, 0.51 inch; November 17, 0.56 inch; November 22, 0.55 inch; and November 26, 0.60 inch. New sand was not put into the filter after October 1.

The filter was raked to a depth of 1 inch on August 29.

The rate of filtration was fluctuated on October 17, 24 and 31.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 44.

Day.	1894.						
	July.	August.	September.	October.		November.	
				Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . . .	-	20	16	105	-	39	0
2, . . .	-	20	-	315	4	26	0
3, . . .	-	22	-	602	4	22	0
4, . . .	-	10	25	378	9	-	-
5, . . .	-	-	12	1,680	23	42	1
6, . . .	-	150	52	250	5	64	7
7, . . .	-	252	18	-	-	66	3
8, . . .	-	34	32	100	0	70	2
9, . . .	-	16	-	103	1	48	1
10, . . .	-	14	-	349	4	104	3
11, . . .	-	16	48	387	2	-	-
12, . . .	-	-	41	-	-	56	2
13, . . .	-	10	62	1,750	27	75	3
14, . . .	-	11	77	-	-	60	1
15, . . .	-	10	105	270	12	58	0
16, . . .	-	14	-	180	6	32	1
17, . . .	-	200	57	130	3	50	3
18, . . .	-	11	50	78	0	-	-
19, . . .	39,500	-	30	67	0	75	1
20, . . .	10,200	17	40	56	0	24	0
21, . . .	3,400	6	45	-	-	27	0
22, . . .	-	14	80	38	0	45	0
23, . . .	1,100	14	-	32	0	14	0
24, . . .	400	13	105	26	0	27	0
25, . . .	800	38	55	41	0	-	-
26, . . .	300	-	131	40	0	30	0
27, . . .	500	30	198	40	3	14	0
28, . . .	50	26	299	-	-	42	0
29, . . .	-	46	170	44	0	-	-
30, . . .	60	19	-	21	0	165	2
31, . . .	50	28	-	20	0	-	-

Monthly Averages of Analyses of Effluent of Filter No. 44.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
July, . . .	7,480,000	77	83	.23	.0054	.0121	.20	.048	.0002	.27	-	2,900
August, . .	7,400,000	74	75	.16	.0004	.0073	.30	.026	.0000	.17	18	28
September, . .	7,400,000	67	71	.10	.0002	.0048	.30	.031	.0000	.19	9	28
October, . .	7,340,000	58	57	.29	.0008	.0097	.26	.028	.0000	.37	38	145
November, . .	7,340,000	44	42	.41	.0030	.0120	.30	.027	.0000	.44	78	45

Filter No. 45.

This intermittent filter was started July 10, 1893, and has contained sand of an effective size of 0.23 millimeter. The normal depth is 60 inches.

From Dec. 8, 1893, to July 20, the filter was out of service. Since the latter date river water has been filtered at a rate of 5,000,000 gallons per acre daily after the regular method of operation of intermittent filters described on the foregoing pages. The height of the trap was raised 12 inches above the top of the under-drains on September 1.

The dates and depths of scraping are as follows: August 14, 0.38 inch; September 3, 0.30 inch; September 17, 1.27 inches; and November 10, 1.14 inches. New sand was put into the filter only on the occasion of the first scraping.

The surface was raked to a depth of 1 inch on the following dates: September 4, 14 and 22, October 3, 9, 19 and 26, November 1, 8, 13, 17, 20, 23, 26 and 29.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 45.

Day.	1894.						
	July.	August.	September.	October.		November.	
				Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . . .	-	16	14	64	-	50	1
2, . . .	-	6	-	174	0	35	1
3, . . .	-	6	-	119	1	20	0
4, . . .	-	15	29	400	3	-	-
5, . . .	-	-	18	379	1	38	0
6, . . .	-	65	29	166	1	51	0
7, . . .	-	40	46	-	-	64	0
8, . . .	-	26	58	99	0	160	4
9, . . .	-	13	-	153	2	110	0
10, . . .	-	20	74	137	4	-	-
11, . . .	-	23	149	634	0	-	-
12, . . .	-	-	37	420	0	130	2
13, . . .	-	15	32	320	1	260	11
14, . . .	-	33	84	-	-	350	11
15, . . .	-	15	214	215	2	210	3
16, . . .	-	18	-	164	4	95	3
17, . . .	-	12	47	153	3	170	0
18, . . .	-	24	39	133	1	-	-
19, . . .	-	-	51	136	0	50	0
20, . . .	10,000	17	32	138	0	70	1
21, . . .	2,200	19	34	-	-	85	0
22, . . .	-	7	59	47	0	36	0
23, . . .	600	21	-	42	0	53	0
24, . . .	400	22	76	38	0	46	1
25, . . .	600	11	52	33	1	-	-
26, . . .	500	-	28	50	0	99	1
27, . . .	300	17	108	95	3	43	1
28, . . .	50	8	54	-	-	28	0
29, . . .	-	8	42	62	1	-	-
30, . . .	15	8	-	46	0	210	0
31, . . .	16	8	-	48	1	-	-

Monthly Averages of Analyses of Effluent of Filter No. 45.

[Parts per 100,000.]

1894.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Deg. F. Applied Water.	Temperature. Deg. F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
July, . . .	5,600,000	77	81	.22	.0008	.0104	.21	.027	.0000	.26	42	100
August, . .	5,100,000	74	75	.16	.0003	.0078	.30	.029	.0000	.18	63	24
September, . .	4,680,000	67	70	.10	.0004	.0054	.30	.048	.0000	.19	52	23
October, . .	4,700,000	58	59	.30	.0006	.0099	.26	.031	.0000	.38	55	88
November, . .	4,680,000	44	41	.44	.0052	.0124	.29	.024	.0000	.44	81	270

Filter No. 46.

This continuous filter was started Aug. 21, 1893, and has contained sand of an effective size of 0.29 millimeter. The normal depth has been 12 inches.

From Dec. 8, 1893, to May 19, 1894, the filter was out of service, and on the latter date was filled with city (filtered) water from below. Beginning May 21, this filtered water was applied to the filter until September 1. The rate of filtration was 2,000,000 gallons per acre daily up to June 29; on June 29 and 30 it was 500,000 gallons; and after July 1 it was 2,500,000 gallons.

On and after September 1 river water was applied to this filter, and on this date the trap was raised to 12 inches above the underdrains.

The dates and depths of scraping are as follows: July 18, 0.30 inch; September 3, 0.24 inch; October 2, 0.32 inch; October 26, 0.42 inch; November 2, 0.32 inch; November 12, 0.43 inch; November 19, 0.49 inch; and November 26, 0.53 inch. No new sand was added after October 2.

The rate of filtration was fluctuated on October 12 and 24, and November 5.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 46.

Day.	1894.											
	May.	June.	July.		August.		September.		October.		November.	
			Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . .	–	462	26	–	12	18	5	0	65	–	10	0
2, . .	–	644	28	–	–	–	–	–	170	–	17	0
3, . .	–	–	30	–	–	13	13	0	165	–	23	0
4, . .	–	381	–	–	7	5	22	0	120	–	–	–
5, . .	–	465	35	–	–	–	24	0	62	–	60	0
6, . .	–	213	68	26	42	16	27	0	45	–	140	1
7, . .	–	227	40	20	22	10	14	0	–	–	120	3
8, . .	–	165	–	–	29	12	15	0	50	–	140	6
9, . .	–	173	40	22	12	4	–	–	55	0	180	2
10, . .	–	–	50	163	20	0	–	–	221	6	330	0
11, . .	–	100	98	115	16	4	–	–	76	3	–	–
12, . .	–	113	86	126	–	–	31	0	221	1	58	0
13, . .	–	108	42	32	26	6	42	0	100	1	300	10
14, . .	–	89	22	39	10	3	34	0	–	–	480	9
15, . .	–	67	–	–	15	2	60	0	53	0	230	7
16, . .	–	69	36	64	22	6	–	–	30	0	120	1
17, . .	–	–	71	84	15	3	18	0	20	1	80	1
18, . .	–	47	64	86	27	0	30	0	9	1	–	–
19, . .	–	55	30	28	–	–	20	0	8	1	86	2
20, . .	–	72	43	24	14	4	22	0	6	0	90	2
21, . .	132,000	60	65	16	109	5	18	0	–	–	90	3
22, . .	14,300	40	–	–	12	0	43	0	11	0	44	1
23, . .	6,700	41	60	17	9	0	–	–	10	0	26	2
24, . .	3,200	–	30	35	168	0	60	0	8	0	52	0
25, . .	4,500	45	17	103	13	0	14	0	11	0	–	–
26, . .	–	32	14	28	–	–	130	0	21	0	78	2
27, . .	–	38	23	21	7	2	115	0	62	0	36	1
28, . .	700	38	12	16	6	0	196	0	–	–	50	0
29, . .	1,000	28	–	–	10	0	110	0	24	0	–	–
30, . .	492	35	20	42	33	0	–	–	5	0	97	1
31, . .	512	–	95	6	8	0	–	–	8	0	–	–

Monthly Averages of Analyses of Effluent of Filter No. 46.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
May, . . .	2,020,000	57	52	.28	.0010	.0106	.24	.033	.0002	.22	-	3,400
June, . . .	1,940,000	67	60	.26	.0010	.0092	.19	.037	.0000	.24	55	189
July, . . .	2,480,000	77	70	.16	.0007	.0081	.22	.033	.0000	.17	40	19
August, . .	2,540,000	74	70	.09	.0006	.0053	.30	.037	.0000	.11	41	36
September, .	2,320,000	67	66	.08	.0002	.0062	.33	.031	.0000	.13	43	63
October, . .	2,480,000	58	56	.24	.0006	.0085	.29	.031	.0000	.29	46	28
November, . .	2,260,000	44	41	.34	.0027	.0107	.24	.021	.0000	.43	77	110

Filter No. 47.

This intermittent filter was started Sept. 9, 1893, and has contained sand of an effective size of 0.29 millimeter. The normal depth is 60 inches.

No water was applied to this filter after draining on Dec. 8, 1893, until July 20, 1894, when river water was applied at the top; after filling the filter with water, filtration was begun at the normal rate of 7,500,000 gallons per acre daily. The method of operation was the same as for the other intermittent filters during this period. On September 1, the trap was raised 12 inches above the underdrains.

The dates and depths of scraping are as follows: August 2, 0.44 inch; August 16, 0.24 inch; August 24, 0.25 inch; September 5, 1 inch; September 24, 0.34 inch; September 26, 1.94 inches; October 9, 0.33 inch; October 12, 0.18 inch; October 13, 3.31 inches; October 19, 0.48 inch; October 26, 0.37 inch; October 30, 0.28 inch; November 6, 0.41 inch; November 12, 0.42 inch; November 15, 0.44 inch; November 17, 1.18 inches; November 19, 1.21 inches; November 24, 0.28 inch; and November 28, 0.57 inch. No new sand was added after October 9.

The surface was raked to a depth of 1 inch on August 29, and 0.5 inch on September 14.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 47.

Day.	1894.						
	July.	August.	September.	October.		November.	
				Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . . .	–	13	44	209	–	28	0
2, . . .	–	135	–	187	1	31	0
3, . . .	–	35	–	128	1	33	0
4, . . .	–	40	8	250	0	–	–
5, . . .	–	–	36	172	0	19	1
6, . . .	–	100	38	350	0	150	0
7, . . .	–	130	57	–	–	270	2
8, . . .	–	105	67	141	0	310	7
9, . . .	–	46	–	151	1	180	2
10, . . .	–	59	102	74	3	–	–
11, . . .	–	40	169	2,800	5	–	–
12, . . .	–	–	58	1,600	3	212	6
13, . . .	–	24	54	2,984	19	410	7
14, . . .	–	13	26	–	–	145	2
15, . . .	–	10	315	440	4	80	1
16, . . .	–	60	–	266	4	92	0
17, . . .	–	40	81	180	3	270	3
18, . . .	–	29	66	83	1	–	–
19, . . .	–	–	88	140	1	560	4
20, . . .	36,000	26	43	190	1	230	5
21, . . .	5,300	19	62	–	–	330	3
22, . . .	–	19	62	38	0	115	1
23, . . .	2,200	16	–	41	0	95	0
24, . . .	1,000	64	46	43	0	70	1
25, . . .	700	40	54	44	1	–	–
26, . . .	150	–	406	52	0	140	0
27, . . .	200	15	251	116	0	103	0
28, . . .	53	14	458	–	–	220	1
29, . . .	–	59	272	82	1	–	–
30, . . .	26	59	–	97	1	840	4
31, . . .	28	25	–	52	0	–	–

Monthly Averages of Analyses of Effluent of Filter No. 47.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid		Nitrates.	Nitrites.			
July, . . .	7,000,000	77	80	.24	.0002	.0088	.21	.027	.0002	.26	56	400
August, . .	7,000,000	74	74	.17	.0004	.0077	.30	.025	.0000	.19	67	24
September, . .	6,900,000	67	70	.10	.0004	.0056	.30	.053	.0000	.19	55	52
October, . .	5,800,000	58	58	.29	.0006	.0091	.26	.041	.0000	.35	70	92
November, . .	5,280,000	44	44	.35	.0014	.0136	.26	.028	.0000	.44	–	104

Filter No. 48.

This filter was started on Sept. 9, 1893, and has contained sand of an effective size of 0.38 millimeter. The normal depth is 60 inches. In 1893 it was operated intermittently.

From Dec. 8, 1893, to May 26, 1894, the filter was out of service. On the latter date it was filled with city (filtered) water from below. Beginning on May 28, it filtered this city water up to October 25, when river water was regularly supplied for the remainder of the season. During the month of June it was operated intermittently in the regular manner; for the rest of the time the operation was continuous. Up to July 1, the rate of filtration was 2,000,000 gallons per acre daily; July 1 to October 15, it was 2,500,000 gallons; and on the latter date it was doubled. The trap was raised in the same way as in the case of the other filters.

The dates and depths of scraping are as follows: October 25, 0.44 inch; November 12, 2.38 inches; November 13, 2.58 inches; November 17, 1.39 inches; and November 19, 2.64 inches. No new sand was put in the filter after scraping.

Fluctuations in the rate of filtration occurred on October 12 and 26, and on November 27.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 48.

Day.	1894.											
	May.	June.	July.		August.		September.		October.		November.	
			Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . .	-	1,100	72	-	13	38	8	0	5	-	71	0
2, . .	-	1,000	22	-	10	21	-	-	6	-	44	0
3, . .	-	-	20	-	17	17	8	0	6	-	17	0
4, . .	-	1,100	-	-	21	16	12	0	5	-	-	-
5, . .	-	1,200	13	-	-	-	12	0	3	-	82	2
6, . .	-	720	75	70	10	20	31	0	3	-	165	4
7, . .	-	700	81	44	20	10	43	0	-	-	170	3
8, . .	-	840	-	-	9	8	15	0	9	-	360	6
9, . .	-	580	-	-	8	13	-	-	2	1	270	4
10, . .	-	-	-	-	5	7	-	-	1	1	445	1
11, . .	-	332	-	-	41	18	-	-	6	2	-	-
12, . .	-	201	-	-	-	-	2	0	4	2	-	-
13, . .	-	110	22	34	10	7	9	1	4	0	-	-
14, . .	-	96	15	44	7	2	5	0	-	-	-	-
15, . .	-	95	-	-	6	8	2	0	3	0	910	42
16, . .	-	161	26	53	20	13	-	-	2	1	1,610	25
17, . .	-	-	20	38	15	9	6	0	3	1	763	14
18, . .	-	132	17	47	23	8	10	0	4	2	-	-
19, . .	-	97	17	28	-	-	4	0	4	2	490	1
20, . .	-	90	29	31	16	1	28	0	3	2	690	2
21, . .	-	140	10	34	5	3	6	0	-	-	250	2
22, . .	-	125	-	-	7	1	4	0	0	1	235	1
23, . .	-	53	15	27	8	0	-	-	5	1	110	0
24, . .	-	-	30	31	12	0	45	-	5	2	89	0
25, . .	-	85	26	38	10	1	50	-	75	3	-	-
26, . .	-	61	21	19	-	-	16	-	230	0	75	2
27, . .	-	49	31	11	12	0	4	-	420	5	90	0
28, . .	7,700	65	23	11	8	0	2	-	-	-	49	0
29, . .	2,000	77	-	-	6	0	12	-	139	2	-	-
30, . .	3,200	122	5	6	4	0	-	-	26	0	280	1
31, . .	2,700	-	16	22	3	1	-	-	83	1	-	-

Monthly Averages of Analyses of Effluent of Filter No. 48.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
June, . . .	2,020,000	67	62	.28	.0006	.0085	.19	.042	.0000	.24	93	680
July, . . .	2,500,000	77	69	.14	.0006	.0063	.22	.039	.0000	.15	50	13
August, . .	2,520,000	74	69	.08	.0004	.0043	.30	.037	.0000	.11	40	19
September, .	2,520,000	67	65	.06	.0001	.0049	.35	.035	.0000	.11	63	2
October, . .	3,800,000	58	56	.23	.0004	.0096	.29	.030	.0001	.30	71	11
November, . .	4,540,000	44	41	.36	.0004	.0132	.24	.020	.0001	.43	79	370

Filter No. 49.

This continuous filter was started on Sept. 9, 1893, and has contained sand of an effective size of 0.38 millimeter. Its normal depth is 60 inches.

From Dec. 8, 1893, to May 26, 1894, the filter was out of service. On the latter date it was filled with city (filtered) water from below. From May 28, it filtered this water continuously up to October 25. The rate of filtration was 2,500,000 gallons per acre daily from May 28 to June 30, and 5,000,000 gallons from July 1 to October 15, after which it was increased to 10,000,000 gallons. The trap was changed to correspond with those of the other filters on September 1.

The dates and depths of scraping are as follows: August 3, 0.33 inch; October 16, 0.37 inch; October 31, 0.41 inch; November 6, 0.47 inch; November 15, 0.43 inch; November 19, 0.71 inch; November 24, 0.49 inch; and November 26, 0.71 inch. New sand was added only on the date of first scraping.

Fluctuations in the rate of filtration occurred on October 12 and 29, and November 27.

Average Daily Number of Bacteria in Effluent of Filter No. 49.

Day.	1894.											
	May.	June.	July.		August.		September.		October.		November.	
			Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . .	-	970	22	-	20	20	6	0	22	-	54	0
2, . .	-	1,400	60	-	-	-	-	-	5	-	43	0
3, . .	-	-	34	-	17	16	6	0	6	-	32	0
4, . .	-	784	-	-	6	40	5	0	14	-	-	-
5, . .	-	540	17	-	-	-	8	0	2	-	24	0
6, . .	-	350	104	54	46	37	34	0	2	-	500	5
7, . .	-	320	59	27	49	48	15	0	-	-	940	4
8, . .	-	206	-	-	22	15	8	0	6	-	714	5
9, . .	-	280	21	14	12	4	-	-	1	4	330	2
10, . .	-	-	29	127	10	5	-	-	3	5	-	-
11, . .	-	84	34	80	13	22	-	-	4	3	-	-
12, . .	-	76	80	48	-	-	6	-	4	3	120	1
13, . .	-	65	20	35	56	16	4	-	13	9	198	1
14, . .	-	37	13	42	14	9	5	-	-	-	238	5
15, . .	-	44	-	-	14	6	6	-	7	7	200	2
16, . .	-	72	12	44	8	30	-	-	9	7	70	1
17, . .	-	-	26	30	9	13	3	-	4	5	64	2
18, . .	-	57	18	24	7	8	7	-	4	3	-	-
19, . .	-	77	17	29	-	-	1	-	5	4	56	1
20, . .	-	76	42	19	12	0	5	-	5	5	58	1
21, . .	-	30	15	28	5	2	7	-	-	-	46	2
22, . .	-	37	-	-	3	0	6	-	5	4	40	1
23, . .	-	55	5	15	3	0	-	-	6	4	45	1
24, . .	-	-	12	34	2	0	9	-	4	4	63	0
25, . .	-	60	70	45	3	0	26	-	60	4	-	-
26, . .	-	95	13	61	-	-	8	-	258	4	75	2
27, . .	-	85	21	31	6	0	3	-	455	4	90	0
28, . .	74,000	67	41	15	3	0	2	-	-	-	49	0
29, . .	9,600	36	-	-	6	0	4	-	150	0	-	-
30, . .	1,400	28	20	5	10	0	-	-	41	1	280	1
31, . .	1,150	-	20	32	3	0	-	-	96	1	-	-

Monthly Averages of Analyses of Effluent of Filter No. 49.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
June, . . .	2,300,000	67	62	.28	.0009	.0088	.19	.041	.0000	.25	54	327
July, . . .	4,800,000	77	68	.16	.0009	.0076	.22	.039	.0000	.15	43	23
August, . .	4,980,000	74	69	.09	.0002	.0048	.30	.038	.0000	.11	43	17
September, .	5,020,000	67	65	.06	.0001	.0048	.36	.036	.0000	.11	61	4
October, . .	7,600,000	58	56	.24	.0018	.0098	.29	.027	.0002	.31	70	33
November, . .	9,520,000	44	41	.35	.0017	.0122	.24	.020	.0000	.43	81	270

Filter No. 50.

This continuous filter was started on July 23, 1894, and has contained sand of an effective size of 0.48 millimeter. It has a normal depth of 60 inches and is constructed of material very similar to that in the older Filter No. 18 A.

The rate of filtration has been 5,000,000 gallons per acre daily. River water was applied to the top on the date when the construction was completed. Filtration was begun at once and the filter has regularly received river water. On September 1 the trap was changed to correspond to those of the other filters.

The dates and depths of scraping are as follows: September 3, 0.42 inch; September 18, 0.35 inch; October 16, 0.43 inch; October 29, 0.49 inch; November 12, 0.42 inch; and November 24, 0.52 inch. No new sand was added after September 18.

Fluctuations in the rate of filtration occurred on October 11, 19 and 26, and November 2, 7, 27 and 28.

Average Daily Number of Bacteria per Cubic Centimeter in Effluent of Filter No. 50.

Day.	1894.						
	July.	August.	September.	October.		November.	
				Water Bacteria.	B. Prodigiosus.	Water Bacteria.	B. Prodigiosus.
1, . . .	–	2,400	420	250	0	43	0
2, . . .	–	2,600	–	315	11	60	0
3, . . .	–	2,500	–	294	2	60	0
4, . . .	–	700	359	357	7	–	–
5, . . .	–	–	298	378	3	70	0
6, . . .	–	4,600	181	588	3	130	1
7, . . .	–	1,500	420	–	–	595	17
8, . . .	–	875	190	315	0	–	–
9, . . .	–	756	–	245	1	130	2
10, . . .	–	900	–	532	0	68	0
11, . . .	–	1,800	420	1,113	0	–	–
12, . . .	–	–	218	–	–	264	2
13, . . .	–	330	200	315	7	170	15
14, . . .	–	410	260	–	–	137	14
15, . . .	–	410	260	167	2	72	1
16, . . .	–	492	–	197	0	80	7
17, . . .	–	345	170	704	1	32	0
18, . . .	–	260	679	85	0	–	–
19, . . .	–	–	245	117	0	24	0
20, . . .	–	340	240	110	0	23	0
21, . . .	–	440	300	–	–	130	0
22, . . .	–	480	210	85	0	40	0
23, . . .	16,000	420	–	82	0	31	1
24, . . .	2,000	300	242	78	0	35	1
25, . . .	3,100	310	120	75	0	–	–
26, . . .	5,000	–	195	96	1	47	0
27, . . .	3,600	510	209	46	0	41	0
28, . . .	1,800	224	370	–	–	60	0
29, . . .	–	364	170	97	0	–	–
30, . . .	8,300	350	–	40	0	58	0
31, . . .	4,600	270	–	46	0	–	–

Monthly Averages of Analyses of Effluent of Filter No. 50.

[Parts per 100,000.]

1894.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
July, . . .	5,100,000	77	81	.07	.0128	.0060	.22	.014	.0002	.20	53	6,400
August, . .	4,840,000	74	73	.16	.0007	.0091	.30	.023	.0000	.15	26	575
September, .	4,780,000	67	68	.14	.0005	.0076	.30	.024	.0001	.19	35	332
October, . .	4,960,000	58	55	.25	.0005	.0091	.28	.031	.0001	.29	44	302
November, . .	4,560,000	44	42	.40	.0071	.0108	.27	.023	.0000	.36	64	39

Lawrence City Filter.

This filter is 2.5 acres in area, and was first put in operation Sept. 20, 1893. The average amount of water filtered and pumped daily has been about 3,000,000 gallons. Under ordinary conditions the surface of the filter is uncovered and the sand drained about eight hours daily. The effluent is pumped to the open distributing reservoir of the city, which is 25 feet deep at high-water mark and has a capacity of 40,000,000 gallons.

Once a week throughout the year chemical analyses of the Merrimack River water, before and after its passage through the filter, as it leaves the reservoir, and from taps at the city hall and experiment station, have been made. Monthly averages of the results of these analyses are presented beyond, together with results of the corresponding bacterial analyses : —

Monthly Averages of Analyses of the Merrimack River Water as it flows upon the Lawrence City Filter.

[Parts per 100,000.]

1894.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.	Bacteria per Cubic Centimeter.
January,	32	.43	.0075	.0186	.0137	.20	.0140	.0001	.43	88	1.5	7,700
February,	32	.39	.0067	.0182	.0162	.21	.0190	.0001	.43	93	1.6	7,600
March,	37	.48	.0026	.0168	.0143	.13	.0110	.0000	.45	100	1.0	6,500
April,	–	.42	.0029	.0157	.0147	.15	.0110	.0000	.40	95	1.3	11,200
May,	57	.48	.0074	.0203	.0165	.15	.0140	.0000	.43	86	1.3	6,000
June,	66	.52	.0071	.0186	.0154	.12	.0090	.0001	46	80	1.4	8,300
July,	75	.39	.0109	.0197	.0157	.19	.0080	.0003	.30	69	1.8	2,400
August,	74	.34	.0094	.0201	.0143	.25	.0080	.0002	.26	52	1.8	3,100
September,	70	.33	.0138	.0200	.0151	.33	.0070	.0004	.27	59	1.9	6,500
October,	56	.40	.0117	.0213	.0162	.27	.0110	.0003	.39	68	2.0	25,300
November,	39	.44	.0085	.0224	.0185	.26	.0160	.0001	.47	88	1.8	16,600
December,	32	.39	.0110	.0215	.0176	.27	.0190	.0001	.44	93	2.1	21,700

Monthly Averages of Analyses of Effluent from the City Filter.

[Parts per 100,000.]

1894.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
January,	1,227,600	34	.34	.0071	.0106	.0102	.20	.0370	.0002	.31	3.0	129
February,	1,218,300	35	.34	.0090	.0099	.0095	.21	.0460	.0001	.29	2.9	244
March,	1,137,200	39	.40	.0121	.0093	.0086	.18	.0450	.0003	.26	3.3	455
April,	996,100	–	.38	.0073	.0097	.0093	.21	.0370	.0000	.31	2.7	281
May,	1,124,000	57	.39	.0080	.0107	.0106	.22	.0410	.0000	.29	2.8	134
June,	1,191,000	65	.40	.0052	.0106	.0097	.20	.0260	.0001	.30	3.3	110
July,	1,251,000	74	.21	.0045	.0074	.0069	.22	.0360	.0001	.19	2.8	25
August,	1,154,000	74	.19	.0046	.0083	.0065	.29	.0340	.0000	.15	2.5	36
September,	1,136,000	70	.26	.0078	.0076	.0062	.38	.0450	.0000	.17	3.4	42
October,	1,178,000	57	.30	.0063	.0083	.0079	.30	.0530	.0000	.25	3.0	116
November,	1,175,000	40	.55	.0174	.0101	.0100	.33	.0390	.0001	.33	4.0	175
December,	1,150,000	35	.37	.0104	.0110	.0089	.28	.0320	.0000	.32	3.1	922

Monthly Averages of Analyses of Water from the Outlet of the Distributing Reservoir.

[Parts per 100,000.]

1894.	Temperature. Deg. F.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.			Nitrates.	Nitrites.			
				Total.	Soluble.						
January,	35	.35	.0054	.0115	.0104	.20	.0320	.0000	.33	2.7	83
February,	34	.34	.0055	.0104	.0101	.21	.0410	.0000	.30	2.7	138
March,	38	.36	.0050	.0097	.0092	.20	.0250	.0000	.27	2.5	179
April,	–	.35	.0032	.0093	.0088	.19	.0200	.0000	.27	2.6	137
May,	57	.35	.0027	.0120	.0109	.20	.0390	.0000	.28	2.4	104
June,	65	.41	.0029	.0095	.0100	.18	.0350	.0000	.30	2.7	81
July,	75	.19	.0017	.0094	.0075	.21	.0300	.0001	.20	2.7	155
August,	73	.17	.0031	.0079	.0075	.29	.0370	.0002	.15	2.7	169
September,	69	.20	.0017	.0081	.0069	.36	.0350	.0000	.15	2.8	80
October,	58	.23	.0018	.0100	.0088	.30	.0380	.0000	.20	2.8	102
November,	40	.35	.0052	.0108	.0092	.29	.0350	.0000	.30	3.1	136
December,	36	.34	.0077	.0104	.0088	.29	.0350	.0001	.30	3.0	366

Monthly Averages of Water from a Tap at the Lawrence City Hall.

[Parts per 100,000.]

1894.	Temperature. Deg. F.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
January,	38	.35	.0066	.0117	.20	.0360	.0000	.32	2.7	51
February,	38	.36	.0043	.0106	.21	.0400	.0000	.30	2.9	102
March,	39	.33	.0048	.0107	.19	.0300	.0000	.27	2.5	92
April,	–	.33	.0031	.0101	.19	.0300	.0000	.27	2.4	100
May,	56	.34	.0018	.0104	.19	.0400	.0000	.27	2.7	129
June,	62	.39	.0018	.0088	.18	.0410	.0000	.29	2.7	95
July,	69	.21	.0006	.0071	.20	.0310	.0000	.20	2.6	92
August,	70	.15	.0004	.0064	.29	.0350	.0000	.12	2.7	142
September,	66	.19	.0004	.0073	.37	.0350	.0000	.15	2.8	85
October,	61	.23	.0005	.0084	.30	.0370	.0000	.20	2.4	81
November,	45	.34	.0033	.0092	.28	.0360	.0001	.30	3.1	72
December,	39	.36	.0062	.0104	.30	.0320	.0000	.29	3.0	346

Monthly Averages of Analyses of Water from a Tap at the Lawrence Experiment Station.

[Parts per 100,000.]

1894.	Temperature. — Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.	Bacteria per Cubic Centimeter.
January,	39	.35	.0027	.0100	.20	.0370	.0000	.32	95	2.5	50
February,	38	.32	.0036	.0098	.21	.0410	.0000	.31	83	2.9	84
March,	39	.34	.0033	.0095	.23	.0430	.0000	.27	80	2.5	150
April,	45	.33	.0023	.0096	.19	.0340	.0000	.27	87	2.4	80
May,	54	.28	.0013	.0100	.20	.0430	.0000	.26	66	2.5	88
June,	59	.35	.0013	.0099	.19	.0380	.0000	.25	64	2.8	102
July,	68	.18	.0005	.0078	.20	.0330	.0000	.20	54	2.7	96
August,	69	.14	.0002	.0062	.30	.0370	.0000	.12	48	2.7	123
September,	66	.16	.0000	.0058	.37	.0350	.0000	.13	65	2.7	76
October,	60	.20	.0001	.0071	.30	.0380	.0000	.18	71	2.5	349
November,	47	.32	.0010	.0100	.28	.0360	.0000	.26	76	3.1	120
December,	40	.36	.0043	.0090	.30	.0330	.0000	.27	88	3.0	244

Daily Bacterial Analyses.

Beginning Dec. 1, 1894, a daily bacterial analysis was made of the Merrimack River water before and after its passage through the filter and as it flowed from taps at the city hall and experiment station. This daily bacterial examination was continued until May, 1895, and the results are presented below.

It must be said in this connection that the winter of 1894–95 was very cold, and the filter was covered with ice a large portion of the time. When it was necessary to relieve clogging, in order to filter the required amount of water, the ice on the beds of the filter nearest the pumping station was removed and these beds scraped. The result of course was a very high rate of filtration for a time, through a limited area of the filter, and hence increased numbers of bacteria in the filtered water. It follows from this that the bacterial results given below are not such as we should have had if the filter had been satisfactorily operated.

The results of observations, in regard to typhoid fever in Lawrence and its relation to the public water supply, will appear in a subsequent report.

Daily Bacterial Results, Lawrence City Water.

[Bacteria per cubic centimeter.]

Date — 1894.	In River Water.	In Filtered Water from				Condition of Surface when Pumps were Stopped.	Loss of Head. — Feet.
		City Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.		
December 1,	-	-	-	-	191	Drained.	6.6
2,	-	-	-	-	-	"	-
3,	12,900	1,190	304	180	141	Covered.	4.7
4,	-	-	-	-	170	Drained.	5.3
5,	-	-	-	-	-	"	5.8
6,	22,000	170	-	220	-	"	6.6
7,	18,600	181	-	270	490	"	6.3
8,	44,100	714	-	360	504	"	6.0
9,	-	-	-	-	-	Covered.	-
10,	35,000	1,190	410	560	375	"	5.4
11,	47,600	430	-	315	296	Drained.	6.9
12,	34,100	490	-	371	340	"	7.2
13,	27,500	315	-	210	220	"	6.8
14,	32,500	390	-	232	280	"	6.7
15,	73,500	525	-	420	320	"	6.2
16,	-	-	-	-	-	Covered.	-
17,	17,000	47	620	518	410	"	7.0
18,	17,600	110	-	410	406	Drained.	6.8
19,	8,500	97	-	224	250	"	6.7
20,	11,000	70	-	197	190	"	7.2
21,	12,200	105	-	185	180	"	7.0
22,	22,000	127	-	165	130	"	7.4
23,	-	-	-	-	-	Covered.	5.0
24,	22,000	160	132	124	51	"	4.0
25,	-	-	-	-	-	"	-
26,	20,500	560	-	144	230	"	3.8
27,	12,500	181	-	200	170	"	5.2
28,	7,600	178	-	232	197	"	4.8
29,	14,500	490	-	157	160	"	5.0
30,	-	-	-	-	-	"	-
31,	9,900	280	175	172	162	"	3.6

Daily Bacterial Results, Lawrence City Water — Continued.

[Bacteria per cubic centimeter.]

Date — 1895.	In River Water.	In Filtered Water from				Condition of Surface when Pumps were Stopped.	Loss of Head. — Feet.
		City Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.		
January 1, . .	13,500	192	-	108	156	Drained.	5.3
2, . .	15,000	115	-	159	182	"	5.3
3, . .	13,600	504	-	159	162	Covered.	4.5
4, . .	14,700	396	-	143	166	Drained.	5.8
5, . .	13,400	418	-	154	152	Covered.	5.7
6, . .	-	-	-	-	-	-	-
7, . .	23,500	140	150	278	230	Covered.	3.8
8, . .	22,700	140	-	225	146	Drained.	6.2
9, . .	55,000	210	-	185	228	"	6.7
10, . .	17,000	243	-	340	260	"	6.5
11, . .	13,600	108	-	158	146	"	6.8
12, . .	17,400	231	-	195	127	"	6.6
13, . .	-	-	-	-	-	Covered.	-
14, . .	19,400	315	210	140	152	"	6.4
15, . .	21,500	190	-	214	209	Drained.	5.6
16, . .	19,700	216	-	149	168	"	5.5
17, . .	15,500	190	-	134	109	"	5.3
18, . .	14,500	136	-	86	100	"	5.2
19, . .	16,600	260	-	150	197	Covered.	5.1
20, . .	-	-	-	-	-	"	-
21, . .	15,600	390	116	73	153	"	4.9
22, . .	31,800	108	-	85	66	"	5.3
23, . .	16,000	71	-	85	114	Drained.	6.9
24, . .	18,000	150	-	92	123	Covered.	7.2
25, . .	14,000	127	-	92	89	"	8.0
26, . .	15,400	160	-	74	60	"	8.9
27, . .	-	-	-	-	-	"	-
28, . .	23,500	127	97	104	78	"	8.6
29, . .	14,000	159	-	108	63	"	9.0
30, . .	17,000	129	-	112	90	"	9.0
31, . .	14,000	130	-	117	97	"	9.0

Daily Bacterial Results, Lawrence City Water — Continued.

[Bacteria per cubic centimeter.]

Date — 1895.	In River Water.	In Filtered Water from				Condition of Surface when Pumps were Stopped.	Loss of Head. — Feet.
		City Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.		
February 1, .	12,100	116	-	115	86	Drained.	7.9
2, .	13,000	135	-	121	147	"	7.9
3, .	-	-	-	-	-	"	5.9
4, .	14,000	305	155	121	126	"	5.0
5, .	13,800	230	-	45	25	Covered.	5.9
6, .	18,000	840	-	250	161	"	5.2
7, .	18,400	476	-	245	157	"	5.7
8, .	26,700	373	-	233	200	"	6.2
9, .	35,000	270	-	220	189	"	7.5
10, .	-	-	-	-	-	"	8.4
11, .	22,700	160	-	95	283	"	8.4
12, .	17,500	98	-	65	150	"	8.8
13, .	13,800	87	-	39	37	Drained.	8.0
14, .	9,400	380	-	48	96	Covered.	7.5
15, .	8,500	88	-	57	72	Drained.	8.3
16, .	12,200	345	155	88	86	Covered.	7.6
17, .	-	-	-	-	-	"	6.0
18, .	12,000	520	-	76	88	"	6.3
19, .	10,700	90	-	70	35	Drained.	8.6
20, .	8,700	74	-	55	51	"	8.7
21, .	9,700	410	-	72	73	Covered.	7.3
22, .	11,300	312	-	50	63	"	5.7
23, .	5,000	234	-	50	74	"	6.0
24, .	-	-	-	-	-	"	5.1
25, .	18,800	420	120	103	99	"	5.8
26, .	18,800	540	-	87	88	"	7.2
27, .	19,400	162	-	94	73	"	7.8
28, .	11,400	132	-	46	47	"	8.4

Daily Bacterial Results, Lawrence City Water — Continued.

[Bacteria per cubic centimeter.]

Date — 1895.	In River Water.	In Filtered Water from				Condition of Surface when Pumps were Stopped.	Loss of Head. — Feet.
		City Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.		
March 1, . .	18,000	122	-	91	68	Covered.	7.8
2, . .	46,000	1,267	-	116	43	"	8.7
3, . .	-	-	-	-	-	"	-
4, . .	24,000	686	-	179	144	"	7.4
5, . .	26,000	616	-	155	80	"	7.5
6, . .	20,000	169	-	98	68	"	7.5
7, . .	24,000	240	205	78	90	"	7.6
8, . .	18,000	165	-	37	101	Drained.	8.0
9, . .	105,000	1,190	-	36	78	Covered.	7.6
10, . .	-	-	-	-	-	"	-
11, . .	17,000	485	-	114	123	"	8.1
12, . .	13,000	235	-	55	89	Drained.	7.8
13, . .	15,000	375	-	93	112	Covered.	7.4
14, . .	16,000	360	-	83	73	Drained.	7.3
15, . .	16,000	690	-	85	131	Covered.	7.5
16, . .	42,000	1,470	-	83	187	"	7.4
17, . .	-	-	-	-	-	"	-
18, . .	16,000	528	358	130	179	"	7.4
19, . .	20,000	310	-	170	215	Drained.	7.5
20, . .	13,000	167	-	160	138	Covered.	7.1
21, . .	10,000	112	-	150	134	Drained.	7.6
22, . .	8,000	135	-	94	87	"	7.5
23, . .	10,000	132	-	83	146	"	7.5
24, . .	-	-	-	-	-	"	-
25, . .	10,000	160	-	126	119	Covered.	7.5
26, . .	13,000	160	-	98	128	"	7.8
27, . .	12,000	194	-	82	98	Drained.	7.5
28, . .	8,000	112	-	92	70	Covered.	7.7
29, . .	8,000	138	-	117	106	"	7.6
30, . .	12,000	315	-	92	98	"	7.5
31, . .	-	-	-	-	-	"	7.6

Daily Bacterial Results, Lawrence City Water — Concluded.

[Bacteria per cubic centimeter.]

Date — 1895.	In River Water.	In Filtered Water from				Condition of Surface when Pumps were Stopped.	Loss of Head. — Feet.
		City Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.		
April 1, . . .	8,000	65	130	90	109	Drained.	7.8
2, . . .	12,000	95	-	114	90	Covered.	7.3
3, . . .	9,000	-	-	90	103	Drained.	7.6
4, . . .	9,000	-	-	80	96	"	7.5
5, . . .	10,000	181	-	63	88	Covered.	7.5
6, . . .	13,000	290	-	82	95	"	7.5
7, . . .	-	-	-	-	-	"	-
8, . . .	12,000	58	115	83	81	"	5.7
9, . . .	19,000	30	-	65	63	"	7.5
10, . . .	11,000	44	-	65	53	"	7.0
11, . . .	7,000	134	-	64	64	"	8.0
22, . . .	7,000	77	70	71	65	"	7.0
23, . . .	6,000	67	-	51	56	Drained.	7.6
24, . . .	7,000	70	-	65	54	"	7.7
25, . . .	4,000	59	-	40	47	"	7.2
26, . . .	7,500	-	-	49	38	Covered.	6.9
27, . . .	5,000	38	-	30	40	"	6.4
28, . . .	-	-	-	-	-	"	-
29, . . .	3,000	22	-	60	39	"	4.4
30, . . .	2,000	37	-	20	35	"	4.5

Monthly Averages of Daily Bacterial Results from the Lawrence City Water.

Months.	Bacteria per Cubic Centimeter in Water from				
	River.	Effluent at Filter.	Reservoir Outlet.	City Hall Tap.	Experiment Station Tap.
1894.					
December, ...	23,800	364	330	267	255
1895.					
January, ...	18,700	206	143	145	142
February, ...	15,040	283	143	102	104
March, ...	20,770	405	281	103	112
April, ...	8,420	84	105	66	68
Averages, ...	17,350	268	200	137	136
Per cent. which the average number of bacteria removed was of the average number of river bacteria.	-	98.46	98.88	99.21	99.22
Per cent. which the average number of bacteria in water was of the average number of river bacteria.	-	1.54	1.12	.79	.78

PHYSICAL AND CHEMICAL PROPERTIES OF SANDS,

WITH

SPECIAL REFERENCE TO THE FILTRATION OF WATER.

BY H. W. CLARK, CHEMIST OF THE LAWRENCE EXPERIMENT STATION.

PHYSICAL AND CHEMICAL PROPERTIES OF SANDS,

WITH SPECIAL REFERENCE TO THE FILTRATION OF WATER.

By H. W. CLARK, Chemist of the Lawrence Experiment Station.

The annual report of the Board for the year 1892 contained an article on this subject,* and it is the present purpose to present as clearly and concisely as possible such additional facts as longer continued experiments and observations have brought to our knowledge.

The former paper showed the importance of an examination and mechanical analysis of materials — soils, sands and gravels — proposed for use in filtering areas, and demonstrated the possibility of foretelling with considerable accuracy their action and value when so used. Our recent studies of the laws of sand filtration and the quantitative and qualitative efficiency of filters, both when new and after a period of use, have served partly to modify but largely to strengthen the earlier conclusions.

Our method for the mechanical analysis of materials is the same as that formerly described, and is quite satisfactory with sands and gravels such as we have studied. With soils and loams the results obtained by elutriation of the finer particles do not, of course, bear an exact relation to results obtained by the same method when applied to the finer particles of a sand, because of the different shape, composition and specific gravity of the soil and loam particles and their strong tendency to flocculate or gather in masses when in water.

These masses act as distinct particles and settle in a manner that

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* Some Physical Properties of Sands and Gravels, with Special Reference to their Use in Filtration. By Allen Hazen.

prevents any very closely drawn distinction between particles of a different weight and size. This tendency to flocculate has been studied and discussed thoroughly by different agricultural chemists, notably Johnson and Hilgard. Roughly it may be stated that the tendency varies inversely as the size of the particles and the temperature of the water, and hence the necessity for a uniform temperature of the water used in the process. Another reason for uniform temperature is the fact that sand grains settle more quickly in warm than in cold water.

Various methods of procedure and various forms of elutriating apparatus are used by different chemists, but the use of a cylindrical settling apparatus and the method of decantation such as we have adopted are generally conceded to give the most satisfactory results.

Results of Analysis.

The mechanical analysis of a sand should make plain to us its capacity and value as a filtering medium in sewage and water purification. This understanding of the real meaning of the analysis can only come by a continued study of the action in actual operation of a number of filters covering a wide range of materials whose analysis is known. In the former paper on the subject a factor was introduced and its importance in interpreting the mechanical analysis described. This factor was denominated the "effective size" of the sand as shown by analysis, and is the maximum diameter in millimeters of the finer ten per cent. of the sand grains. It has been proved to aid largely in establishing an opinion quickly and accurately of the value of a sand for use in sewage purification, and can be used to calculate with considerable accuracy, by means of a formula, the volume of water that can pass through a given area of sand in a given time under known conditions.

The formula used in this calculation is $V = cd^2 \frac{h}{l} \left(\frac{t \text{ Fahr.} + 10}{60}\right)$ where V is the volume of water in million gallons per acre daily, c is a constant factor, d is the effective size of sand grain in millimeters, h is the loss of head, l is the thickness of sand through which water passes, and $\left(\frac{t \text{ Fahr.} + 10}{60}\right)$ is a factor for temperature correction.

The value of factor c was given in the former article as 1,070. It has been learned, however, that physical and chemical properties of the sand exert controlling influences which must be taken into consideration in all calculations of the volume of water that can pass

through a given area of sand with a given loss of head, when the sand is in actual use in a filter. Prominent among these controlling factors or conditions are the following: —

Increased compactness of the sand due to settling and surface pressure.

Chemical composition of the sand.

Presence of loam and fine particles.

Effect of uniformity coefficient.

Length of time during which the sand has been in use in the filter.

Settling.

In the summer of 1893 three water filters were started, each five feet in depth and containing sand of an effective size of 0.26, 0.29 and 0.38 millimeter respectively. To these was added in 1894 a filter of the same depth and containing sand of an effective size of 0.48 millimeter.

The mechanical analyses of these sands were as follows: —

Number of Filter.	Effective Size of Sand. — Millimeter.	Uniformity Coefficient.	Per Cent. by Weight Finer than (Millimeters)						
			0.105	0.184	0.316	0.462	0.93	2.04	3.89
43, . . .	0.26	3.7	1.5	5.3	14.3	26.0	55.4	84.0	99.0
44, . . .	0.29	2.7	0.9	3.7	12.1	31.0	75.0	97.0	100.0
48, . . .	0.38	3.5	0.5	1.6	6.2	17.6	49.5	80.0	98.0
50, . . .	0.48	2.4	0.2	0.5	2.1	9.0	58.0	91.4	100.0

Determinations of the frictional resistance of these sands to the passage of water when first in position in the filters were made according to the method given on page 552 of the report of 1892. These determinations showed that all of the sands had at that time a quantitative capacity or maximum rate, as great or greater than that given by the formula mentioned above. These observations of frictional resistance have been continued with the sands of these filters, and a summary of the results obtained is presented in the following table.

It must be mentioned here that the results obtained from the sand of Filter No. 44 appear to be largely modified by the chemical composition of the sand, as will be explained later.

Maximum Rate of Flow in Million Gallons per Acre Daily, with Loss of Head Equal to the Depth of the Sand.

Number of Filter.	Effective Size of Sand (Millimeter).	Date of Construction.	Rate at Date of Construction.	Rate Oct., 1893.	Rate Oct., 1894.	Rate June, 1895.
Filter No. 43, . .	0.26	May 20, 1893.	75.0	48.0	40.0	40.0
No. 44, . .	0.29	May 20, 1893.	85.0	55.0	35.0	31.0
No. 48, . .	0.38	Sept. 9, 1893.	155.0	130.0	92.0	72.0
No. 50, . .	0.48	July 23, 1894.	250.0	-	226.0	216.0

The figures of the table are averages of many closely agreeing determinations. The given rates at date of construction are of little significance and are given principally to show how misleading figures obtained within a few days of placing the sand in situ are. This reduction of quantitative capacity we believe to be almost entirely due to the increased compactness caused by the settling of the whole body of the sand. Of course the increased friction was due to some extent to the increased stickiness of the grains due to the deposition of organic matter and bacterial growth and changes, but the determinations of frictional resistance were all made in the lower portions of each filter where organic matter had accumulated very slightly, as shown by chemical analyses of the sand (pages 599–604).

Compactness at the Surface.

The upper half foot, more or less, of a sand filter has a tendency to become more compact than the rest of the filter, caused both by the silting or accumulation of fine particles and organic matter in the pores of the sand, and by the compression and consequent packing and cementing due to the pressure of the water on the surface. Certain filters at the station have become so compact that the prescribed amount of water could not pass even after scraping and removing several inches of the surface sand; relief being given only after spading over. Mechanical analysis of the deepest layer scraped showed no increase of fine particles, and the organic matter present would account for but a small part of the increased frictional resistance. It was due to compactness caused by pressure.

In November, 1894, a few days after finishing scraping the Lawrence city filter, when nearly an inch of the surface sand was removed, the filter would not allow the usual and required amount of water to

pass through it, and the surface was loosened to a depth of six inches to give the necessary porosity. In this case the compactness was, doubtless, largely owing to the tramping down of the sand by the laborers while scraping and replacing the sand, but in our small experimental filters no such cause for compactness exists.

Chemical Composition of Sand.

The mechanical analysis of a sand divides it into portions in which the grains are approximately of equal size and thus gives information in regard to the coarseness or fineness of it, but does not indicate anything concerning its chemical composition. Recent observations, however, lead us to believe that the percentage of aluminous and calcareous material present in a sand has a decided influence upon its frictional resistance to the passage of water. This applies not only to fine sands but also to sands of the grade most often used for water filtration.

In partial explanation of this it may be said that clay is a very fine soil, the chief basis of which is silicate of aluminum, and is almost impermeable to water. This impermeability is, apparently, due not only to its fineness, but also to its absorptive action towards water and the formation of hydrous aluminum silicate, the consequent decrease of the open space of the material giving increased frictional resistance to the passage of water. The finest particles of a clay, that portion known as colloidal clay, when freshly precipitated by brine is gelatinous and very similar to a mixed precipitate of iron and aluminum oxides. Its volume diminishes greatly on drying and it swells like glue when water is applied. It is principally hydrous aluminum silicate but probably contains other bodies with absorptive powers similar to those of clay.

Of course no phenomena of so pronounced a character as just described takes place in any sand selected for use in our experimental filters, but that a slight excess of aluminous material in or on the surface of the sand grains, especially when accompanied by a slight excess of calcareous material, exerts considerable influence is strongly indicated by a comparison of observations of the frictional resistance to the passage of water of the sands of Filters Nos. 43 and 44.

These two filters contain five feet in depth of sand of an effective size of 0.26 and 0.29 millimeter respectively, and these sizes should give, according to the formula and the use of 1,070 as the value of c,

maximum rates of 72,000,000 and 90,000,000 gallons per acre daily respectively. As a matter of fact, however, repeated observations of the loss of head at known rates of filtration have shown that the sand of Filter No. 44, the coarser of the two by mechanical analysis, has the greater frictional resistance to the passage of water and hence the smaller maximum rate, as will be seen by examination of the table already given.

Chemical analysis of the two sands shows that the sand grains of Filter No. 44 taken as a whole contain slightly more alumina than the sand grains of Filter No. 43 taken as a whole; and those grains in Filter No. 44 which have a diameter less than 0.18 millimeter contain nearly twice as much as the similar grains of Filter No. 43, or 0.95 and 1.75 per cent. respectively. The sand of Filter No. 44 contains, by Schloesing's method, 0.75 per cent. of calcium carbonate and that of Filter No. 43, 0.36 per cent.

It may be mentioned here that Filter No. 44 has always been a more efficient filter in removing bacteria than Filter No. 43. In 1894 the effluent of Filter No. 44, filtering Merrimack River water at an average rate of 7,500,000 gallons per acre daily, contained as an average only 0.70 per cent. of the number of the applied bacteria, while the effluent of Filter No. 43, filtering at an average rate of 4,500,000 gallons per acre daily, contained as an average 1.16 per cent. of the number of the applied bacteria.

A very white North Carolina sand examined at this laboratory, a medium fine sand having an effective size of 0.20 millimeter, would allow only one-third of the volume of water to pass through it that its mechanical analysis indicated as its maximum rate. Chemical analysis showed that it contained 1.25 per cent. of alumina and 2.10 per cent. of calcium carbonate by Schloesing's method, and the finer particles had a marked pasty feeling and appearance when wet.

These mixtures of clayey, calcareous and silicious particles when in the right proportion in a soil or sand behave in a manner similar to cement; that is to say, the sand of Filter No. 44 and the white sand last mentioned always cling together in lumps when dried after saturation with water, while most sands fall apart in separate grains when treated in the same manner. This cementing is much more marked in the white sand than any other we have examined and is a phenomenon not entirely understood but obviously very important, as showing the great cohesion particles of some sands have for each other under favorable conditions.

Probably no more favorable condition could exist for sands of this nature to develop their maximum frictional resistance than in a filter which is being used to purify polluted water containing considerable organic matter, for here the sand grains are being gradually covered with a thicker gelatinous film of organic and mineral matter the longer the sand continues in use. The sand of Filter No. 44 is steadily decreasing in quantitative capacity while other filter sands of a harder nature have reached a nearly stationary or very slowly decreasing capacity.

Effect of Uniformity Coefficient on Maximum Rate.

The uniformity coefficient is the ratio of A to B where the values of A and B are such that 60 per cent. of the material is finer than A and 10 per cent. finer than B. An examination of the tables given will show that the sand of Filters No. 43 and 48 have a uniformity coefficient of 3.7 and 3.5 respectively, while the sand of Filter No. 50 has a uniformity coefficient of 2.4. The chemical analyses of these sands show them to be nearly identical in composition. Now if we examine the table showing maximum rates of flow at different dates we see that the present maximum rate of flow of Filter No. 43 is but 53 per cent. of what it was during the first week or two of its use, and the maximum rate of flow of Filter No. 48 is but 47 per cent. of what it was at first. On the other hand the maximum rate of flow of the sand of Filter No. 50 is 93 per cent. of what it was at first.

As has been stated before, the measurements of frictional resistance to the passage of water were all made in the lower half of the filter where complications from the accumulation of organic matters were almost entirely avoided, and these greater reductions of quantitative capacity in the case of Filters No. 43 and 48, as compared with Filter No. 50, are believed to be due to their greater compactness, caused by their greater uniformity coefficient.

If a filter was filled with sand, all of whose grains were spherical and of the same size, they would take their most compact position very quickly and the open space would not be reduced except by the accumulation of foreign matter. On the other hand, if they were irregular in shape and size they would reach their most compact condition more slowly and, the greater their irregularity, the greater their variety in shape and size, the more closely compacted they

could become. This compacting is of course aided by the flow of water through the sand, agitation of the sand caused by the escape of air and filling the filter slowly with water from below after scraping.

Presence of Loam.

A small percentage of loam mixed with a sand increases the frictional resistance of the sand to the flow of water and thus decreases its maximum rate. This loam is generally detected in the mechanical analysis because of its fineness and consequent collection on the finest sieves, but it sometimes occurs as a thin coating on the sand grains in such manner as to be almost invisible and is not shaken off during sifting. It would of course be a fruitful source of sub-surface clogging in a water filter, and if such sand is to be used the loam should first be removed by washing.

In the bank from which the sand for the Lawrence city filter was obtained, a number of pockets or layers of sand were found apparently of a grade suitable for use but whose value was lessened by this coating of loam on the grains.

Conclusions.

From a careful study of the accumulated evidence of our investigations on the flow of water through sand, it would appear that all calculations and estimates of the rate at which water can be filtered through a given sand with the use of a given head should be based upon the frictional resistance that sand will have when it has reached its normal condition of compactness in a filter. Its quantitative capacity at that time is its true capacity, or maximum rate, whatever may be the results obtained during the first few days or weeks of its use.

Its maximum rate cannot be determined by any set value for factor c for all sands, but experience with Filter No. 50, and other shorter experiments, have indicated that 800, when the values of h, d and l are the same as given before, will approximate its value for sands whose uniformity coefficient is low.

For sands whose uniformity coefficient is as high as is the case with Filters No. 43 and 48, the use of 550 as the value of c would give more nearly their true maximum rate.

These conclusions are for such sands as we have used; sands from other localities might, and probably would, give different results.

FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

The following report embraces the operations of the Board relating to food and drug inspection, for the year ending Sept. 30, 1894, under the provisions of the Acts of 1882 and 1883.

The force employed in this department of work was as follows: —

Dr. CHARLES P. WORCESTER,	*Analyst.*
Prof. CHARLES A. GOESSMANN,	*Analyst.*
Mr. ALBERT E. LEACH,	*Assistant Analyst.*
JOHN H. TERRY,	*Inspector.*
JOHN F. McCAFFREY,	*Inspector.*
HORACE F. DAVIS,	*Inspector.*

The whole number of samples of food and drugs (including milk) examined during the year was 6,874, making the total number examined since the beginning of work under the provisions of the food and drug acts 60,477.

The following summary embraces the work done during the year: —

Number of samples of milk examined,	3,551
Number of samples above standard,	1,794
Number of samples below standard,	1,757
Percentage of adulteration or deficiency,	49.5
Number of samples of other kinds of food (not milk),	2,836
Number of samples above standard,	2,566
Number of samples below standard,	270
Percentage of adulteration,	9.5
Number of samples of drugs examined,	487
Number of samples of good quality,	324
Number of samples adulterated, as defined by the statutes,	163
Percentage of adulteration,	33.5
Total number of samples of food and drugs examined,	6,874
Total number found to be of good quality,	4,684
Total number not conforming to the statutes,	2,190
Percentage of adulteration,	31.9

It will not be necessary to detail in full the reasons for the differences in the foregoing figures between the percentages of adulteration which are found upon examination to exist in relation to milk and other articles of food, since the cause of the great discrepancy has been made sufficiently plain in previous reports. It is sufficient therefore to state here that the percentage of adulteration of milk (nearly one-half of the whole number of samples, or 49.5 per cent.) largely represents natural deficiencies and not artificial adulteration; in other words, a very large portion of the milk as produced at the dairies is below the legal standard when first drawn from the cow.

The following summary presents the statistics of the work done under the food and drug acts for the entire period of twelve years ending with Sept. 30, 1894: —

STATISTICAL SUMMARY.

Food and Drug Inspection (1883–94).

Summary.	Years. 1883.	1884.	1885.	1886.	1887.	1888.
Number of samples of milk examined,	218	1,123	2,219	2,085	3,081	2,825
Number of samples above standard,	35	347	1,297	1,323	1,900	1,705
Number of samples below standard,	183	776	922	762	1,181	1,120
Percentage of adulteration,	83.9	69.1	41.7	36.5	38.3	39.6
Number of samples of other kinds of food (not milk),	477	839	1,552	1,353	1,789	2,070
Number of samples of good quality,	328	432	883	863	1,263	1,680
Number of samples adulterated, as defined by the statutes,	149	407	669	490	556	399
Percentage of adulteration,	31.2	48.5	43.1	36.2	29.4	19.2
Number of samples of drugs examined,	603	682	1,007	888	550	862
Number of samples of good quality,	357	431	571	463	400	634
Number of samples adulterated, as defined by the statutes,	246	251	436	425	150	228
Percentage of adulteration,	40.8	36.8	43.3	47.8	27.3	26.4
Total examinations of food and drugs,	1,298	2,644	4,778	4,326	5,420	5,766
Total examinations of good quality,	720	1,210	2,751	2,649	3,563	4,019
Total examinations not conforming to the statutes,	578	1,434	2,027	1,677	1,857	1,747
Percentage of adulteration,	44.5	54.2	42.7	38.7	34.3	30.3
Expense of collection, examination and prosecution,	$2,931 56	$5,529 60	$8,557 43	$8,025 34	$8,803 62	$8,915 41
Expense of collection, examination and prosecution, per sample,	2 26	2 09	1 79	1 85	1 62	1 54

FOOD AND DRUG INSPECTION (1883-94) — *Concluded.*

SUMMARY.	Years.						
	1889.	1890.	1891.	1892.	1893.	1894.	TOTALS.
Number of samples of milk examined,	3,219	3,236	2,726	3,271	3,073	3,551	30,627
Number of samples above standard,	1,971	1,858	1,629	1,757	1,545	1,794	17,161
Number of samples below standard,	1,248	1,378	1,097	1,514	1,528	1,757	13,466
Percentage of adulteration,	38.7	42.6	40.2	46.3	49.7	49.5	44.0
Number of samples of other kinds of food examined (not milk),	1,635	2,349	2,144	2,441	3,009	2,836	22,503
Number of samples of good quality,	1,242	1,913	1,577	2,042	2,637	2,566	17,426
Number of samples adulterated, as defined by the statutes,	393	436	567	399	372	270	5,077
Percentage of adulteration,	24.0	18.6	26.4	16.3	12.3	9.5	22.6
Number of samples of drugs examined,	600	400	424	487	327	487	7,317
Number of samples of good quality,	503	325	352	312	228	324	4,900
Number of samples adulterated, as defined by the statutes,	97	75	72	175	99	163	2,417
Percentage of adulteration,	16.2	18.7	17.0	35.9	30.3	33.5	33.0
Total examinations of food and drugs,	5,454	5,985	5,294	6,199	6,409	6,874	60,447
Total examinations of good quality,	3,716	4,096	3,558	4,111	4,410	4,684	39,487
Total examinations not conforming to the statutes,	1,738	1,889	1,736	2,088	1,999	2,190	20,960
Percentage of adulteration,	31.9	31.5	32.8	33.7	31.2	31.9	34.7
Expense of collection, examination and prosecution,	$10,356 28	$10,013 04	$10,019 41	$11,180 30	$10,454 11	$10,364 64	$105,150 74
Expense of collection, examination and prosecution, per sample,	1 89	1 67	1 89	1 80	1 63	1 52	1 74

The foregoing table shows the entire cost of enforcement of the food and drug acts for the twelve years 1883–94 to have been $105,150.74. The average cost of examination of each sample, when all expenses are considered, for the whole period, was $1.74. This, however, includes the whole cost of collection and analysis, with such other expenses as were incurred under the provisions of the statutes, including the cost of complaints entered at court, and the employment of counsel in a few cases only.

It also appears that the average cost per sample has been reduced from $2.26 in the first year (1883) to $1.52 in the last year (1894). There was a slight increase in 1889, which was followed by a gradual and comparatively uniform decrease in the average cost from that year until the date of the present report.

The actual improvement secured by the operation of the food and drug act, and the advantage which the people of the State derive therefrom, cannot be precisely stated from the foregoing figures, for reasons which have been fully detailed in previous reports. It is sufficient to remark that the action of Massachusetts in this direction has been very highly commended, not only by the officials of the United States government who have similar work under their charge, but also by the executive authorities of other States of the Union, many of which have enacted laws similar to our own, but have failed to make the appropriations essential to their enforcement.

The work of the Board in this department in the earlier years following the enactment of the adulteration acts was done at considerable disadvantage, in consequence of the necessity of dividing it between several different laboratories located in different places. After nearly ten years of divided work this principal portion of the food and drug inspection of the State was brought under the supervision of one analyst and into one laboratory, at 994 Washington Street; and finally, at the close of 1894, the entire work, with the exception of the examination of the milk of western Massachusetts, was removed to the new laboratory in the State House Annex, where it is now conducted. The great advantage of this concentration can only be best appreciated by those who are intimately concerned in its execution.

The report of the analyst, which follows this introductory statement, contains certain points which are worthy of special comment. In addition to the usual routine statement relating to the amount of work done in the examination of different articles of food, a special

statement is presented of the results of analysis of 36 samples of cream obtained from retail dealers.

The paragraph relating to spices is specially noteworthy, since it shows that only 9 per cent. of the whole number was found to be adulterated. This is a smaller percentage than that of any previous year, and shows the actual benefits derived from this law better than in the case of other articles of food, since the samples of spices were obtained during the different years under comparatively uniform conditions. It goes without saying that the number of wholesale spice dealers in Massachusetts who take pride in the production of pure goods has largely increased since 1883.

The following table presents the percentage of adulteration found in examination of spices obtained by the inspectors of the Board from 1883 to 1894, inclusive: —

Years.	Per Cent. of Adulteration.	Years.	Per Cent. of Adulteration.
1883, ...	65.3	1889, ...	15.4
1884, ...	50.3	1890, ...	13.3
1885, ...	48.3	1891, ...	17.3
1886, ...	34.0	1892, ...	13.6
1887, ...	25.1	1893, ...	14.0
1888, ...	16.5	1894, ...	9.0

The statement of the analyst in regard to the examination of the contents of tin cans containing articles of food is worthy of serious consideration. The report shows that analyses were carefully made, and indicated not only the presence of tin but also that quantitative analyses were made proving that the amounts of this metal were present in quite appreciable quantities. The following statement of the analyst is repeated in full, since it has an important bearing upon the subject: —

The poisonous nature of tin salts in small doses, as established by experiments on animals, is unquestioned. It would seem a reasonable inference that so large an amount as 250 milligrammes (calculated as $Sn\ O_2$) in a can of 650 cubic centimeters contents is not a safe constituent of this food.

An important part of the present report is that which relates to the inspection of intoxicating liquors used as beverages. Hitherto,

nearly if not quite all of the examinations of wines and liquors have been confined to those which were sold as drugs and were obtained at the drug stores. The quality of these has been made the subject of special comment in previous reports, and especially in that of 1885 (seventh supplement, Health, Lunacy and Charity).

The following paragraph from the second section of the food and drug act, as amended by chapter 171 of the Acts of 1886, includes all articles used as beverages under the term "food," and for the purposes of the act makes intoxicating drinks *legally* articles of "food," independently of the physiological aspect of the question: —

The term "food," as used herein, shall include confectionery, condiments and all articles used for food or drink by man. (Acts of 1882, 263, § 2; 1886, 171.)

With this statute in view, a collection of liquors was made from the saloons and drinking-places of the principal cities. This collection included the different kinds of distilled liquors, ale, beer and cider, to the number of 175.

The results of the analysis show (1) that intoxicating liquors used as beverages are quite as liable to adulteration as other articles which are legally classed as "food;" and (2) that the adulterations are mainly of a harmless character, the chief harmful or poisonous ingredient being the alcohol which they contain.

The examinations of liquors used as beverages confirm the following statements previously made in the reports of the Board relative to the quality of liquors sold as drugs: —

These examinations have also shown the falsity of a popular impression . . . that the harmful effect of the habitual use of alcoholic stimulants is due to the adulterations to which they are subjected rather than to the alcohol which they contain. It is sufficient to say that such statements have no foundation in fact. (Seventh supplement, 1885, pages 81, 82.)

Not a single sample of adulterated spirits, in the popular understanding of that term, that is, one containing a more injurious ingredient than alcohol itself, was met with, although very few were exactly what they purported to be.

Referring to wines the analyst says: —

Fortunately, as in the case of the spirits examined, alcohol has been the most injurious ingredient found present in the samples. (Report of the analyst of drugs, seventh supplement, 1885, pages 184, 186.)

The great and serious harm to which a very large part of the population is constantly exposed by the consumption of intoxicating liquors is undoubtedly due almost entirely to the alcohol contained in them and not to other ingredients, either natural, accidental or of a fraudulent nature.

Milk Inspection.

The statutes provide that "not less than three-fifths" of the appropriation under the food and drug acts must be expended in the enforcement of the laws relating to the adulteration of milk and milk products, thus recognizing the importance of these articles as constituents of the food supply.

While the enforcement of these laws undoubtedly exercises a degree of influence in promoting the public health, it must be admitted that the chief result of the execution of the laws is of a commercial character; that is to say the adulteration of milk is considered mainly as a commercial fraud, while the actual harm done to the consumer by the various processes which impoverish the milk is apt to be overlooked. Hence the dishonest milk producers and the milk vendors usually have a much greater dread of the exposure of their criminal acts and the resulting penalty than they have of the more rare occurrence, the loss of trade, which occasionally follows the outbreak of some infectious disease among the consumers of milk. It has not infrequently happened that the milk vendor who finds his business suddenly diminishing bitterly complains that the health officials are injuring him, when as a matter of fact the loss of business had already begun before the matter had come to the notice of the sanitary authority, since the public, who are gradually becoming more enlightened in regard to public health questions, had noticed the coincidence of the outbreak with the route of some milkman, and reasonably regarded these circumstances as being in the line of cause and effect.

In a later part of this report may be found further investigations in this direction by Prof. W. T. Sedgwick, in addition to those which were published by the same author in the report of the Board for 1892 relative to typhoid epidemics due to infected milk supplies in Springfield and Somerville. These epidemics show conclusively the need of legislation which shall provide for the sanitary care and inspection of dairies with the same degree of efficiency as now exists in those statutes which were enacted to prevent the adulteration of milk.

The following quotation from the "London Lancet" (1894, page 992) refers to the English epidemic which is mentioned by Professor Sedgwick on a later page: —

A farm on which there had been a case of typhoid fever furnished milk to the creamery. This milk was of course mixed with that of the other patrons and separated, the patrons taking the skim-milk home. Out of about twenty-four farms dealing with the creamery twelve suffered with the disease, while all the farms in that district not dealing with it — about one hundred and eighty — escaped except two, and the infection was indirectly conveyed to these. The persons attacked had been in the habit of drinking the skim-milk. Of the twelve farms which escaped the epidemic, on some the skim-milk was not used without boiling, and on the others it was given only to young cattle and pigs. Farmers in the infected district who carried their milk to another creamery were not attacked. Of twenty-three cases which occurred in the town in the district, nineteen used skim-milk and the remaining four had milk from the infected dairies. In all — in the town and rural district — there were sixty-one cases of typhoid fever, "every one of which was capable of being easily traced back to the imported one. Fifty-two contracted the disease directly through the creamery, and the remaining nine indirectly by means of food or milk from dairies which became infected secondarily."

To account for the infection of the milk from the first case, the author found that the person attacked with the disease was nursed by one of the dairy maids, "and in several of the dairies subsequently visited I found the dairy maids acting in the dual capacity of milkers and nurses; in fact, I saw sufficient to convince me that if the infection once got on the hands it had every opportunity of eventually reaching the milk."

In regard to the germs of the disease the author says: —

"The typhoid bacillus measures about the ten-thousandth part of an inch, and Dr. Klein has demonstrated that it is capable of doubling its numbers in thirty minutes. A streak of these, therefore, on the finger, a quarter of an inch in length and of microscopical width, will contain about twenty-five hundred germs, and if they find their way into the milk they will number about forty thousand at the end of two hours, — quite sufficient to spread disease broadcast through all the dairies around any butter factory."

The author emphasizes the liability of spread of infectious diseases, as scarlet-fever, diphtheria, cholera, etc., through the medium of creameries, where even a single patron is careless; and concludes that "wherever a creamery exists, there a sanitary policeman should secure the proper management of the dairies." He cites the stringent rules of the Denmark creameries, imposing fines upon any patron delivering milk during an outbreak of an infectious disease in his family or stock.

Warning Notices to Retailers.

The following list embraces the names of the cities and towns to which notices were sent during the year, stating that the parties to whom they were sent were found to be retailing food and drugs which were found to be below the required standard of purity.

This form of notice was adopted by the Board at the beginning of its work under the food and drug acts. It is not required by the statutes, and is usually sent only to retailers in cases where there is presumptive evidence that the retailer may not be aware of the fact that the articles which he sells are below the standard of purity required by the statute. Failure to receive such notice in any given case, however, cannot be understood as relieving the retailer from liability to complaint at court.

Cities and Towns to which Notices were sent on Account of Adulterated Drugs.

Boston,	12	Milford,	1
Chelsea,	1	North Adams,	1
Chicopee,	1	Salem,	1
Fall River,	3	South Framingham,	2
Fitchburg,	1	Springfield,	1
Gloucester,	1	Woburn,	1
Lowell,	2		
Marblehead,	1	Total,	29

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food other than Milk.

Avon,	2	Plymouth,	1
Boston,	43	Provincetown,	1
Brookline,	1	Readville,	1
Cambridge,	4	Salem,	2
Chelsea,	2	Somerville,	1
Fall River,	1	Springfield,	3
Lowell,	2	Taunton,	6
Lynn,	2	Ware,	1
Marblehead,	2	Watertown,	1
Northampton,	1		
Pittsfield,	1	Total,	78

Cities and Towns to which Notices were sent on Account of Adulterated Milk.

Beverly,	2	Nantasket,	2
Boston,	14	Natick,	3
Brockton,	1	Newton,	7
Brookline,	7	North Adams,	3
Cambridge,	19	North Reading,	7
Chelsea,	30	Peabody,	2
Dedham,	3	Provincetown,	5
Everett,	3	Quincy,	5
Fall River,	13	Readville,	1
Fitchburg,	3	Revere,	15
Gloucester,	7	Salem,	8
Hingham,	1	Salisbury,	2
Holyoke,	1	Somerville,	32
Hyde Park,	3	Stoneham,	1
Lawrence,	4	Taunton,	1
Littleton,	6	Upton,	1
Lunenburg,	1	Waltham,	9
Malden,	18	Winchester,	7
Marblehead,	9	Winthrop,	5
Marlborough,	2	Woburn,	7
Medford,	9	Worcester,	2
Melrose,	3		
Mendon,	2	Total,	287
Milford,	1		

Prosecutions.

In the reports of the last two years a condensed summary was presented, showing the number of prosecutions conducted in each year since the beginning of work under the food and drug acts. The following table presents the same figures, with the addition of those for the year ending Sept. 30, 1894: —

Number of Complaints Entered in Court.

Year.	Food not including Milk.	Drugs.	Milk.	Total.	Convictions.	Fines Imposed.
1883,	–	5	4	9	8	–‡
1884,	2	1	45	48	44	–‡
1885,*	50	1	68	119	103	–‡
1886,†	10	–	10	20	19	–‡
1887,	30	–	34	64	60	–‡
1888,	22	–	43	65	61	$2,042 00
1889,	74	–	66	140	124	3,889 00
1890,	78	–	24	102	96	3,919 00
1891,	96	5	49	150	135	2,668 00
1892,	52	12	72	136	123	3,661 70
1893,	26	3	67	96	92	2,476 00
1894,	14	–	76	90	77	2,625 00
Totals,	454	27	558	1,039	942	$21,280 70

* To May 1, 1886. † Four months only. ‡ No record kept.

Ratio of convictions to complaints, 90.7 per cent.

Note. — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

The following report was presented to the Legislature in January, 1895, in compliance with the provisions of the statutes: —

Office of the State Board of Health,
State House, Boston, January, 1895.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The following summary is made in compliance with the provisions of chapter 289, section 2, of the Acts of 1884, requiring the State Board of Health to "report annually to the Legislature the number of prosecutions

made under chapter 263 of the Acts of 1882, and an itemized account of all money expended in carrying out the provisions thereof."

The whole number of prosecutions made by authority of the Board against offenders, under the provisions of the food and drug acts, for the year ending Sept. 30, 1894, was 90.

The cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles found to be adulterated, or fraudulently sold, the dates of the trials and their result, are presented in the following table: —

Milk and Milk Products.

For Fraudulent Sales of Milk.

Place.	Date.	Result.
In Boston,	Dec. 1, 1893,	Convicted.
Boston,	Dec. 21, 1893,	"
Boston,	Jan. 26, 1894,	"
Boston,	April 7, 1894,	"
Fall River,	Oct. 19, 1893,	"
Fall River,	Oct. 19, 1893,	"
Fall River,	Oct. 19, 1893,	"
Fall River,	Nov. 1, 1893,	"
Fall River,	June 28, 1894,	"
Fall River,	June 28, 1894,	Acquitted.
Fall River,	July 25, 1894,	Convicted.
Fall River,	July 25, 1894,	"
Fall River,	Aug. 7, 1894,	"
Fall River,	Aug. 21, 1894,	"
Fall River,	Sept. 19, 1894,	"
Fall River,	Sept. 19, 1894,	Acquitted.
Fall River,	Sept. 28, 1894,	Convicted.
Fall River,	Sept. 28, 1894,	"
Lynn,	Nov. 3, 1893,	Acquitted.
Lynn,	Nov. 3, 1893,	"
Lynn,	Nov. 3, 1893,	"
Lynn,	Nov. 3, 1893,	"
Lynn,	Nov. 3, 1893,	"
Lynn,	Nov. 3, 1893,	"
Lynn,	Nov. 3, 1893,	"
Somerville,	July 6, 1894,	Convicted.
Somerville,	July 13, 1894,	"
Somerville,	July 13, 1894,	"
Somerville,	Sept. 8, 1894,	"
Chelsea,	Nov. 2, 1893,	Acquitted.
Chelsea,	Sept. 28, 1894,	Convicted.
Springfield,	Oct. 27, 1893,	"
Quincy,	Dec. 14, 1893,	"

For Fraudulent Sales of Milk — Concluded.

Place.	Date.	Result.
In Quincy,	Dec. 30, 1893,	Convicted.
Quincy,	May 26, 1894,	"
Quincy,	May 26, 1894,	"
Newton,	March 24, 1894,	"
Newton,	March 24, 1894,	"
Waltham,	Feb. 19, 1894,	"
Malden,	March 13, 1894,	"
Fitchburg,	July 26, 1894,	"
Fitchburg,	July 26, 1894,	"
Fitchburg,	Aug. 22, 1894,	"
Fitchburg,	Aug. 22, 1894,	"
Salem,	Aug. 17, 1894,	"
Salem,	Aug. 2, 1894,	"
Salem,	Sept. 30, 1894,	"
Lincoln,	Oct. 4, 1893,	"
Holliston,	Oct. 7, 1893,	"
Framingham,	Dec. 21, 1893,	"
Framingham,	March 8, 1894,	"
Walpole,	Dec. 12, 1893,	"
Walpole,	Dec. 13, 1893,	Acquitted.
Wrentham,	Dec. 13, 1893,	"
Canton,	Dec. 14, 1893,	Convicted.
Revere,	Feb. 23, 1894,	"
Revere,	Aug. 28, 1894,	"
Concord,	Aug. 26, 1894,	"
Burlington,	May 16, 1894,	"
Winchester,	May 17, 1894,	"
Winchester,	May 21, 1894,	"
Hingham,	Aug. 3, 1894,	"
Dedham,	Aug. 13, 1894,	"
Dedham,	Aug. 13, 1894,	"
Bedford,	Aug. 2, 1894,	"
Peabody,	Aug. 17, 1894,	"
Peabody,	Aug. 17, 1894,	"
Peabody,	Aug. 17, 1894,	"
Peabody,	Sept. 20, 1894,	"
Danvers,	Sept. 20, 1894,	"
Nahant,	Sept. 21, 1894,	"
Nahant,	Sept. 21, 1894,	"
Nahant,	Sept. 21, 1894,	"
Provincetown,	Aug. 24, 1894,	"
Chesire,	Sept. 27, 1894,	Acquitted.
Westport,	Sept. 19, 1894,	Convicted.

For Fraudulent Sales of Other Articles of Food.

Molasses.

Place.	Date.	Result.
In North Adams,	Oct. 23, 1893,	Convicted.
North Adams,	Oct. 23, 1893,	"
Lowell,	July 25, 1894,	"

Coffee.

Place.	Date.	Result.
In North Adams,	Oct. 23, 1893,	Convicted.
Chicopee,	Nov. 17, 1893,	"

Cream of Tartar.

Place.	Date.	Result.
In West Gardner,	Nov. 15, 1893,	Convicted.
Salem,	Aug. 2, 1894,	"

Honey.

Place.	Date.	Result.
In Boston,	May 29, 1894,	Convicted.

Mustard.

Place.	Date.	Result.
In Boston,	Oct. 27, 1893,	Convicted.
Taunton,	Jan. 11, 1894,	"
Taunton,	Jan. 18, 1894,	"
Taunton,	Jan. 18, 1894,	"

Pepper.

Place.	Date.	Result.
In Boston,	Oct. 27, 1893,	Convicted.
Chicopee,	Nov. 17, 1893,	"

Summary.

Complaints entered in court under the acts relating to the inspection of milk and milk products,	76
Other articles of food,	14
Total,	90

The whole number of complaints entered by the State Board of Health during the year ending Sept. 30, 1894, in the courts of the Commonwealth, against parties for violation of the statutes relating to food and drug inspection was 90.

In 77, or 85.5 per cent., of these the parties were convicted. Thirteen were discharged either in the district, municipal or superior courts. Of this number 7 occurred in one city and under unusual circumstances.

Of the whole number, 76 were for violation of the laws relating to milk adulteration, and of this number 63 resulted in conviction. The greater number of these was for violation of the statute providing that milk offered for sale shall be of good standard quality.

In 2 of the foregoing cases the complaint was for sale of milk from cans not properly marked, and 1 of these was an adulterated skimmed milk. Two cases were for sales of milk containing coloring matter, and 1 contained boracic acid.

Of the 14 complaints for fraudulent sales of other kinds of food, all of the parties were convicted. The articles of food embraced in this list were as follows: —

Molasses, 3 cases; coffee, 2 cases; mustard, 4 cases; cream of tartar, 2 cases; honey, 1 case; pepper, 2 cases.

The standard of whole milk in Massachusetts is 13 per cent. of solid residue, except in May and June, when it is 12 per cent. The following list presents the total solids in all the samples of milk upon which complaints were founded, so far as records of the same were kept: —

5.41	10.00	10.48	10.72	11.08	11.40	11.54
6.89	10.02	10.50	10.88	11.10	11.46	11.62
8.90	10.06	10.55	10.90	11.20	11.46	11.63
9.17	10.10	10.60	10.92	11.20	11.49	11.70
9.30	10.10	10.62	10.95	11.20	11.50	11.72
9.31	10.20	10.64	10.96	11.27	11.53	11.95
9.46	10.21	10.64	10.99	11.30	11.53	12.00
9.76	10.32	10.68	11.00	11.30	11.54	
9.94	10.40	10.69	11.05	11.34	11.54	
9.94	10.40	10.69	11.07	11.40	11.54	

The total number of samples of food and drugs examined during the year was as follows: —

Milk,	3,551
Other articles of food,	2,836
Drugs,	487
Total,	6,874

Total expenses of collection, examination and prosecution,	$10,364 64
Average expense per sample collected,	1 52

Fines.

The amount of fines paid into the treasuries of counties, cities and towns under the provisions of the general and special laws relative to the inspection of food and drugs was as follows: —

Fines paid for Violation of the Food and Drug Acts, upon Cases entered for the Year ending Sept. 30, 1894.

Under the provisions of the laws relating to milk and milk products,	$2,507 00
Under the provisions of the laws relating to other articles of food,	118 00
Total,	$2,625 00

Expenditures.

Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1894.

	For the Enforcement of the Statutes relating to Food and Drug Inspection.	
	Relative to Milk and Milk Products.	Relative to Other Kinds of Food and Drugs.
Salaries of analysts,	$2,750 00	$1,750 00
Salaries of inspectors,	2,500 00	1,400 00
Travelling expenses and purchase of samples,	998 05	661 95
Apparatus and chemicals,	141 20	64 20
Furniture and fittings at laboratory,	1 95	–
Legal services,	5 00	–
Gas,	12 00	8 00
Extra services,	30 00	18 00
Milk-cans, tags, washing windows and sundry small supplies,	24 29	–
	$6,462 49	$3,902 15
		6,462 49
Total,	. . .	$10,364 64

SAM'L W. ABBOTT,
Secretary.

REPORT OF DR. C. P. WORCESTER, ANALYST.

REPORT OF DR. C. P. WORCESTER, ANALYST.

Dr. S. W. Abbott, *Secretary of the State Board of Health.*

Dear Sir: — I have the honor to report the analysis of foods and drugs for the year beginning Oct. 1, 1893, and ending Sept. 30, 1894.

The Laboratory.

The work of this department has been done during the last year in the temporary laboratory at 994 Washington Street, Boston. At the close of the year we moved into the permanent laboratory which was just completed on the fifth floor of the State House Extension.

This laboratory, which was specially designed to meet our requirements, consists of two rooms lighted by south windows and also by skylight. These two rooms are provided with asphalt floors, which are shellacked to facilitate cleaning. They are ventilated by a four-foot exhaust fan, which is driven by an electric motor and which draws from a system of ventilators and hoods in both rooms.

The larger room, sixty by twenty-five feet, is subdivided into an inspector's anteroom fitted with lockers for samples, a dark room for storage and for work with the spectroscope and polariscope, a separate balance room and a photographic dark closet. There are sixty-eight feet of tiled workbenches with sinks, one of which is hooded, small hoods for various purposes, glass cases, cupboards, etc.

Milk.

The total number of milk samples analyzed during the year has been 3,368, or 295 more than last year. Of this number all but 169 samples, which are from suspected producers, are from dealers in cities and towns chiefly in the eastern part of the State. Forty-nine per cent. are below the standard, a number which closely agrees with similar averages for years past. It must be said that so large a number of samples taken from dealers at random represents fairly the quality of the milk supply of the State. This percentage of 49 below the standard includes some samples of milk of standard quality which had been purposely adulterated; but it is apparently true that

the samples of this class are comparatively very few, and that this percentage of samples below the standard represents nearly the quality of the milk as produced.

If, as is asserted by farmers, it is not difficult to maintain a 13 per cent. milk as the mixed product of a herd, it is apparent that a greater effort is needed to call the attention of the milk producers to the desirability or to the necessity of improving the quality of their herds. If, on the other hand, 13 per cent. of solids is an impracticable standard, the fact should be squarely recognized and met.

The total solids have been determined by evaporation in every case, and the fat has been determined by the Babcock process in such samples as have fallen below 12 per cent. of total solids. This process is proving itself widely useful, not only to the chemist but also to the dairy man, as a ready means of accurately determining the fat value of milk. It is found in practice that the fat will separate in a much cleaner and more satisfactory manner if the milk is at a low temperature when mixed with the sulphuric acid, especially in warm weather.

Two milk samples were found to be preserved with boracic acid and 16 were found to be colored with annatto.

The following tables show the quality of the milk collected from cities, towns and suspected producers, and examined at this laboratory, as well as the quality of the milk by months: —

Milk from Cities.

Cities.	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. Below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.
Boston,	217	123	94	43.3	10.20	2
Brockton,	21	18	3	14.3	11.64	–
Cambridge,	275	110	165	60.0	10.18	2
Chelsea,	215	77	138	64.2	8.76	5
Everett,	36	18	18	50.0	10.70	–
Fall River,	217	128	89	41.0	9.30	–
Fitchburg,	92	41	51	55.4	10.20	–
Gloucester,	57	27	30	52.6	9.23	–
Haverhill,	24	11	13	54.2	12.20	–
Lawrence,	35	15	20	57.1	9.60	–
Lynn,	23	7	16	69.6	10.53	–
Malden,	101	41	60	59.4	9.49	–
Marlborough,	31	16	15	48.4	11.50	1
Medford,	151	82	69	45.7	10.22	1
Newton,	154	95	59	38.9	10.68	3
Quincy,	65	32	33	50.7	8.14	–
Salem,	128	77	51	39.8	9.17	–
Somerville,	302	158	144	47.6	9.95	–
Taunton,	36	34	2	5.6	11.65	–
Waltham,	84	42	42	50.0	10.92	–
Woburn,	76	40	36	47.3	11.14	–
Worcester,	32	14	18	56.2	10.48	–
Totals,	2,372	1,206	1,166	49.2	8.14	14

Milk from Towns.

Towns.	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. Below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.
Adams,	23	13	10	43.0	11.10	1
Bourne,	10	5	5	50.0	12.22	–
Brookline,	121	72	49	40.5	11.38	–
Canton,	9	8	1	11.1	11.85	–
Dedham,	69	37	32	46.3	9.46	–
Gardner,	12	4	8	66.6	12.02	–
Hull,	20	7	13	65.0	10.50	–
Hyde Park,	108	57	51	47.2	10.20	–
Marblehead,	23	6	17	73.9	10.00	–
Melrose,	12	9	3	25.0	11.44	–
Milford,	12	3	9	75.0	11.46	–
Nahant,	14	5	9	65.0	11.15	–
Natick,	24	13	11	45.8	11.22	–
Norwood,	9	6	3	33.3	11.18	1
Peabody,	39	15	24	61.5	8.90	–
Provincetown,	25	7	18	72.0	10.32	–
Randolph,	11	7	4	36.3	12.35	–
Reading,	12	5	7	58.3	11.17	1
Revere,	76	33	43	56.5	10.46	–
Salisbury,	14	9	5	35.7	11.14	–
Stoneham,	45	35	10	22.2	12.70	2
Stoughton,	31	20	11	35.5	12.12	–
Watertown,	4	3	1	25.0	9.35	1
Winthrop,	42	18	24	57.1	11.26	1
Winchester,	50	17	33	66.0	10.06	–
Westborough,	12	11	1	8.3	12.68	1
Totals,	827	425	402	48.6	8.90	8

Milk from Suspected Producers.

Towns.	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. Below Standard.	Total Solids in Lowest Sample.
Bedford,	20	3	17	85.0	10.48
Concord,	16	3	13	81.2	11.07
Framingham,	17	2	15	88.2	10.09
Littleton,	32	1	31	96.8	11.34
Marlborough,	5	0	5	100.0	11.48
Mendon,	12	0	12	100.0	10.26
Natick,	16	6	10	62.5	11.82
Reading,	12	2	10	83.3	11.76
Waltham,	36	1	35	97.2	10.60
Wrentham,	3	1	2	66.6	10.30
Totals,	169	19	150	88.7	10.09

Summary of the Three Preceding Tables.

	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. Below Standard.	Lowest Sample.	Number of Skimmed Samples.
Cities,	2,372	1,206	1,166	49.2	8.14	14
Towns,	827	425	402	48.6	8.90	8
Suspected producers,	169	19	150	88.7	10.09	–
Totals,	3,368	1,650	1,718	51.0	8.14	22

Quality of Milk by Months.

Months.	Total Samples Collected.	Above 13 Per Cent.	Below 13 Per Cent.	Below 12 Per Cent.	Per Cent. of Adulteration, 13 Per Cent. Standard.	Per Cent. of Adulteration, 12 Per Cent. Standard.
October,	248	126	122	32	49.2	12.1
November,	190	82	108	29	56.8	15.3
December,	205	85	120	22	58.5	10.7
January,	161	84	77	28	47.8	17.4
February,	181	73	108	28	59.6	15.5
March,	391	188	203	52	51.9	13.3
April,	305	126	179	33	58.7	10.8
May,	311	105	206	41	66.2	13.1
June,	355	132	223	51	62.8	11.5
July,	487	125	362	131	74.3	26.9
August,	311	114	197	64	63.3	20.6
September,	223	81	142	50	63.7	22.4
Average,	-	-	-	-	59.4	15.8

Cream.

Since buttermakers have been using the Babcock process for determining the fat contents of milk they have also applied it to the determination of the butter value of cream. It is found that there is a great variety in the composition of ordinary dairy "space cream," which is practically the same thing as the old-fashioned skimmed cream. Since the centrifugal method of separating cream has come into universal use the variation in the fat value of the cream on the market is very wide. The dealers roughly distinguish a light or thin cream from a heavy, and charge accordingly; but there is no standard requiring a minimum amount of fat by which some uniformity in the value of the article may be insured.

The following tables show the quality of samples of cream bought at random from retail dealers and restaurants, being classified as "heavy" and "light" cream. From the somewhat wide variation in the amount of fat in cream sold at the same price, ranging from thirty-six to forty-eight per cent. in the case of heavy and from eight to twenty-one per cent. in the case of light cream, it would seem on all accounts desirable that some statute standard for fat should be established.

Two samples of cream were found to be preserved with boracic acid.

"*Heavy*" *Cream.*

Inspector's Number.	Brand.	Per Cent. Fat.	Per Cent. Solids not Fat.	Per Cent. Solids.	Price per Half Pint.	Where Purchased.
					Cents.	
1595,	Bangor,	46.40	5.48	51.88	15	Store.
5863,	- - -	45.74	4.68	50.42	15	"
4961,	Deerfoot Farm,	45.60	7.64	53.24	20	"
4979,	Oak Grove Farm,	45.60	6.10	51.70	20	"
5547,	- - -	45.10	4.20	49.30	15	"
1591,	Dirigo,	43.00	4.30	47.30	15	"
16865,	Hampden,	42.60	6.48	49.08	15	"
17091,	- - -	42.30	3.02	45.32	15	"
1593,	Dirigo,	41.80	5.05	46.85	15	"
5053,	- - -	41.60	7.34	48.94	15	"
5051,	- - -	41.20	7.62	48.82	15	"
5141,	Hampden,	40.80	5.40	46.20	15	"
16850,	- - -	40.20	9.04	49.24	15	"
4967,	Dirigo,	39.80	6.82	46.62	15	"
17052,	- - -	39.63	7.85	47.48	15	"
5125,	- - -	38.60	6.60	45.20	15	"
16878,	Hampden,	38.40	7.34	45.74	15	"
4963,	- - -	38.10	8.50	46.60	15	"
Average,		42.02	6.30	48.32	-	-

"*Light*" *Cream.*

Inspector's Number.	Per Cent. Fat.	Per Cent. Solids not Fat.	Per Cent. Solids.	Price per Half Pint.	Where Purchased.
				Cents.	
5061,	21.60	7.90	29.50	8	Milkman.
4983,	19.50	7.94	27.44	8	Restaurant.
4981,	18.90	7.22	26.12	10	Store.
4987,	18.40	7.84	26.24	10	Restaurant.
4993,	17.60	7.86	25.46	10	"
4985,	16.80	7.70	24.50	8	"
4973,	16.35	8.00	24.35	8	"
4971,	16.20	7.75	23.95	8	"
4965,	15.30	7.36	22.66	8	Store.
5055,	12.60	8.03	20.63	10	"
4995,	10.40	8.40	18.80	8	Restaurant.
5059,	10.20	9.46	19.66	7	"
4989,	10.10	8.46	18.56	7	"
5057,	9.80	9.58	19.38	8	"
4969,	9.90	9.30	19.20	8	"
4975,	9.00	8.54	17.54	8	"
4977,	8.30	9.05	17.35	8	"
4991,	8.60	8.11	16.71	5	"
Average,	13.86	8.25	22.11	-	-

Butter.

Three hundred and six samples were received, and all proved to be genuine.

Cheese.

Twenty samples of cheese were found to be of good quality.

Lard.

Forty-six samples were of good quality and six were adulterated with tallow and cotton-seed oil.

Olive Oil.

Forty-six samples were of good quality and 11 consisted chiefly or wholly of cotton-seed oil.

Vinegar.

Twenty-nine samples conformed to the statute standard and 27 failed to do so.

Spices.

Of ground spices, 1,287 samples have been examined during the year, and of this number but 125, or 9 per cent., proved to be adulterated. Of last year's samples, 14 per cent. were found to be adulterated. This improvement of the quality of ground spices sold in the State has been going on steadily since the food inspection was begun in 1883, at which time 65 per cent. of the samples of ground spice submitted were found to be adulterated.

The sale of adulterated spices under cover of the "compound" act continues to a limited extent. It could scarcely have been the intention of the framers of this act to authorize the use of a label on which one reads in large type "Pure ginger ground," and in small letters appears the word "compound." Again, the familiar package of Colman's mustard, which consists largely of wheat flour, bears the statement "it is perfectly pure," besides the word "compound." It is difficult to conceive of sophistry which could justify this statement

regarding its purity side by side with the admission of its adulteration.

A similar assertion as to the purity of adulterated goods is occasionally found on a package with no accompanying confession of the compound nature of the article.

Allspice.

One hundred and four samples were of good quality, 3 were adulterated. The adulterant found was ground nut-shell, of which the worst sample contained 40 per cent.

Cassia.

One hundred and fifty seven samples were of good quality, 7 were adulterated. The adulterants were wheat, corn, nut-shells and saw-dust. The worst sample contained 80 per cent. of the three first named adulterants.

Cayenne.

The percentage of adulteration of cayenne is much greater than that of any other spice. It appears to be a very common practice to grind capsicum with corn, perhaps for convenience of handling, the corn starch acting as an oil absorbent. Of the samples examined, 59 were found genuine and 25 were adulterated. The adulterants were corn and wheat, and the worst sample was 60 per cent. adulterated.

Cloves.

One hundred and ninety-eight samples were genuine, 6 were adulterated. The adulterants were corn, wheat, nut-shells and sand. The worst sample was 50 per cent. adulterated.

Ginger.

One hundred and fifty-seven samples were of good quality, 7 were adulterated. The adulterants were wheat, corn and turmeric. The worst sample was 80 per cent. adulterated.

Mace.

Thirty-four samples, all genuine.

Mustard.

One hundred and eighty-nine samples were found genuine, 59 were adulterated. The adulterants were wheat, corn, turmeric and gypsum. The worst sample was 75 per cent. adulterated.

Nutmeg.

One sample, of good quality.

Pepper.

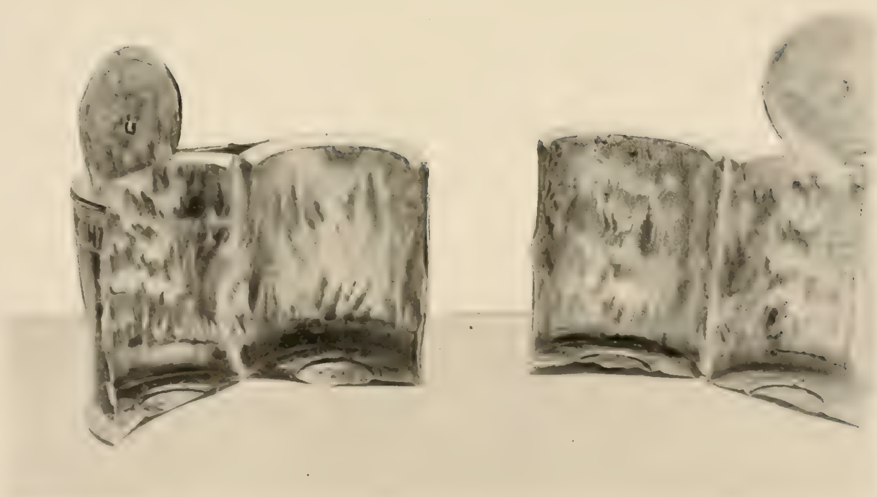
Two hundred and sixty-six samples were genuine, 18 were adulterated. The adulterants found were buckwheat, wheat, rice, cayenne, beans, nut-shells, turmeric and sand. The worst sample was 75 per cent. adulterated.

Canned Goods.

Eighteen samples, including condensed milk, were found of good quality, and 3 were found to contain metallic impurities. Of the latter number were samples of canned grapes. The corroded condition of the inside of these cans suggested that a good deal of the tin had been dissolved off by the acids of the grape juice. It was found that the juice contained in one instance 0.037 grammes of tin in solution (calculated as $Sn\ O_2$). In addition a variety of canned fruits and vegetables were examined to determine the quantity of tin contained in solution, with the result that, though considerable traces were found in acid fruits and rhubarb and large traces in some cans of green vegetables, such as string beans, canned blueberries were found to contain much more tin in solution than any other canned goods examined. It is assumed that the tin was, at least in considerable part, still held in solution by the fruit acids, inasmuch as the metal was found in the filtered juice. In every instance the inner tin lining of the can was found to be extensively corroded, and in some instances it had been almost entirely dissolved off, leaving the underlying iron bare. Plate I. shows the appearance of two of these cans split open to show their inner surfaces. The corrosion is apparent.

The following is a summary of the quantity of tin found in solution in the eleven cans examined: —

PLATE I.



BLUEBERRY CANS

Cut open to show the corrosion of the tin by the fruit acids.

Canned Blueberries.

Inspector's Number.	Brand.	Amount of Tin per Can in Solution (calculated as SnO_2).
		Gramme.
839,	Eagle,	0.27
887,	Raymond's,	0.26
0214,	Morrison's Heather,	0.208
981,	Young's,	0.206
831,	Wyman's Fancy,	0.149
953,	Eagle,	0.114
889,	Saguenay,	0.096
695,	Wyman's Fancy,	0.094
833,	Wyman's Fancy,	0.094
837,	Saguenay,	0.086
955,	Ferguson's,	0.066

In no instance was the presence of lead appreciable.

The poisonous nature of tin salts in small doses, as established by experiment on animals, is unquestioned. It would seem a reasonable inference that so large an amount as 250 milligrammes (calculated as Sn O_2) in a can of 650 cubic centimeter contents is not a safe constituent of this food.

Condensed Milk.

Thirteen samples were examined for solids and fat, with the results as follows: —

Condensed Milk.

Inspector's Number	Brand.	Per Cent. Solids.	Per Cent. Solids not Fat.	Per Cent. Fat.	Per Cent. Water.
4124,	Watch,	68.85	64.85	4.00	31.15
16303,	Tip Top,	74.60	67.90	6.70	25.40
16381,	Highland,	75.40	67.75	7.65	24.60
5143,	Maine Jersey,	68.32	61.05	7.27	31.68
5065,	Dirigo,	70.70	64.75	5.95	29.30
5085,	Full Weight,	76.68	68.85	7.73	23.32
4932,	Winners,	71.66	66.19	4.47	28.34
4749,	Interstate,	68.76	64.58	4.18	31.24
5494,	Gold Medal,	74.33	66.50	7.83	25.67
6001,	J. B. Smith,	69.60	64.75	4.85	30.40
6070,	Clover,	74.23	68.25	5.98	25.77
6042,	Pine Tree,	73.08	69.20	3.88	26.92
6474,	Leader,	73.15	70.00	3.15	26.85

Chocolate.

Eleven samples were found to contain their proper constituents without addition, 5 samples contained added corn or wheat starch and sugar.

Confectionery.

Fifty-five samples contained proper constituents, such as sugar, glucose, starches and gums, together with non-injurious colors and flavors; one sample contained turpentine, which was doubtless intended for oil of lemon.

Coffee (Ground).

Seventy samples were genuine, 26 were adulterated. Adulterants found were peas, wheat, chicory, oats, pea shells, sticks and stones. The worst sample contained no coffee.

Cream of Tartar.

Three hundred and fourteen samples were found of good quality, 7 were adulterated. The adulterants were corn and wheat starch, gypsum and phosphate of lime. The worst sample contained 50 per cent. of gypsum.

Honey.

Thirty-five samples were genuine and 5 adulterated with glucose syrup. The worst sample contained 40 per cent. of glucose syrup.

Molasses.

One hundred and forty-eight samples were genuine and 18 were adulterated with glucose. The worst sample was 60 per cent. adulterated.

Maple Syrup.

Thirty samples were genuine, 1 was adulterated with glucose syrup.

Maple Sugar.

Thirty-four samples were genuine, 3 were adulterated with crude molasses sugar.

Syrup.

One sample genuine, 1 adulterated with glucose.

Tea.

Eighty-six samples found to be genuine, 7 were of poor quality, containing tea dust and earthy ingredients.

Miscellaneous.

Under this head are included samples of baking powder, containing alum; saleratus, containing considerable amount of chloride; mince-meat, containing a considerable quantity of salicylic acid as a preservative; dried cod fish and "fresh" oysters preserved with boracic acid; and a sample of "Perfection milk preservative," costing 40 cents per pound and consisting of borax worth 15 cents. Of this class 122 samples were found of good quality and 24 were found adulterated or containing injurious ingredients.

Summary of Food Statistics

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Allspice,	104	3	107	2.8
Butter,	306	0	306	0.0
Canned goods,	18	3	21	14.3
Cassia,	157	7	164	4.3
Cayenne,	59	25	84	29.7
Cheese,	20	0	20	0.0
Chocolate,	11	5	16	31.2
Cloves,	198	6	204	2.9
Coffee,	70	26	96	27.0
Confectionery,	55	1	56	1.8
Cream,	30	2	32	6.2
Cream of tartar,	314	7	321	2.1
Ginger,	157	7	164	4.2
Honey,	35	5	40	12.5
Lard,	46	6	52	11.5
Mace,	34	0	34	0.0
Maple sugar,	34	1	35	2.9
Maple syrup,	30	1	31	3.2
Miscellaneous,	122	24	146	16.5
Molasses,	148	18	166	10.9
Mustard,	189	59	248	23.8
Nutmeg,	1	0	1	0.0
Olive oil,	46	11	57	19.3
Pepper,	266	18	284	6.3
Syrups,	1	1	2	50 0
Tea,	86	7	93	7.5
Vinegar,	29	27	56	4.8
Totals,	2,566	270	2,836	9.5

Liquor.

An effort has been made to determine the quality of the liquor sold in the ordinary city saloon over the bar. To this end samples of whiskey, brandy, rum, gin, ale, beer and cider were collected, these samples being bought by the bottle or glass at various saloons, and paid for, thus representing what is actually sold every day to ordinary patrons. The analysis of these samples was made with the view of determining their relation to accepted liquor standards of strength, and also with a view of detecting any injurious ingredients or additions.

There appears to be a popular idea that most saloon liquor is poisonous, and that most of the evil effects of intemperance are directly caused by the poor quality of the ordinary saloon stock. The conclusions to which this investigation has led are, however, that the hard liquors usually differ from the standards chiefly in containing too much water or sugar, and that ingredients more injurious than alcohol are rarely to be found in appreciable amount. Fusel oil in noxious amount is occasionally to be found, and it is also rarely present to a distinctly appreciable extent in beer. It appears to be a common custom to preserve ale and beer by the addition of salicylic acid. The use of this drug for this purpose is everywhere recognized as harmful and unjustifiable.

The following tables show the results of the analyses of 37 samples of whiskey, 37 samples of brandy, 40 samples of rum, 33 samples of gin, 6 samples of cider, 7 samples of pale ale and 15 samples of beer, the samples in each table being arranged with reference to the amount of alcohol by weight which they contain, and preceded, for comparison, by the best-recognized standard, wherever there is such a standard.

Whiskey.

Inspector's Number.	Percentage of Alcohol by Weight.	Percentage of Extract.	Excess of Acidity, Tannin, Fusel Oil, etc.
STANDARD,	44 to 50	0.25 or less.	
19665,	45.96	1.11	
19615,	45.80	1.68	.03 per cent. of tannic acid.
19719,	42.70	0.22	Consists chiefly of brandy; excess of tannic acid.
19634,	42.30	0.19	
19627,	41.70	0.22	
19656,	41.30	0.17	
19645,	40.30	4.33	Chiefly brandy.
19610,	40.20	1.17	Excess of tannic acid.
19784,	40.20	0.11	
19685,	40.10	1.39	Excess of tannic acid.
19641,	10.00	0.86	Excess of tannic acid.
19630,	39.80	0.35	
19649,	39.30	0.16	
19681,	39.25	1.07	
19117,	38.80	0.13	
19682,	38.56	0.45	
19614,	37.90	0.60	
19630,	37.90	0.90	Residue chiefly insoluble.
19725,	37.60	0.14	
19022,	36.30	0.13	
19631,	36.00	0.44	
19721,	36.00	0.13	Residue chiefly insoluble.
19718,	36.00	0.28	
19633,	35.70	0.92	
19653,	35.50	0.12	Tannic acid absent.
19660,	35.50	0.13	Tannic acid absent.
19663,	35.20	0.38	
19608,	35.00	1.81	Fusel oil present.
19778,	35.00	0.17	
19639,	33.70	0.11	
19626,	33.70	0.63	Excess of tannic acid.
19635,	32.50	0.13	Tannic acid absent.
19623,	32.50	0.10	
19617,	31.60	1.13	Excess of tannic acid.
19633,	30.70	0.65	
19627,	30.70	0.09	
19628,	30.70	0.08	

Brandy.

Inspector's Number.	Percentage of Alcohol by Weight.	Percentage of Extract.	Excess of Acidity, Tannin, Fusel Oil, etc.
STANDARD, ...	39 to 47	1.5 or less.	
19675, ...	50.70	0.97	Acidity one-sixth in excess.
19648, ...	50.50	3.00	Tannin in excess.
19661, ...	44.90	2.15	Tannin in excess.
19686, ...	44.80	0.56	Acidity two-fifths in excess.
19629, ...	44.40	0.13	Acidity one-half in excess.
19679, ...	44.00	0.25	Excess of tannin.
19667, ...	43.19	0.53	
19652, ...	43.00	0.23	
19782, ...	42.80	0.38	
19687, ...	42.70	0.88	
19680, ...	42.60	2.11	Acidity two-fifths in excess.
19647, ...	42.50	1.08	Acidity one-fifth in excess.
19637, ...	42.30	0.20	Acidity one-fifth in excess.
19636, ...	42.00	0.91	Tannin in excess.
19653, ...	42.00	0.15	
19652, ...	41.80	0.27	Acidity (acetic) one-third in excess.
19612, ...	41.70	0.99	
19632, ...	41.50	0.22	Acidity one-fifth in excess.
19620, ...	41.50	0.10	Residue insoluble.
19659, ...	41.50	0.49	Largely whiskey.
19773, ...	41.50	0.44	Contains fusel oil, and acidity one-sixth in excess.
19683, ...	40.90	0.81	Clove flavor.
19629, ...	40.50	0.20	
19684, ...	40.20	1.04	
19619, ...	39.80	0.14	
19648, ...	39.50	0.66	
19770, ...	39.30	0.24	
19775, ...	38.90	0.71	
19768, ...	37.90	0.67	Chiefly alcohol, water and sugar.
19661, ...	37.60	0.61	Fusel oil, excess of tannin and residue insoluble.
19656, ...	37.60	0.15	
19643, ...	37.30	1.57	Chiefly whiskey.
19766, ...	35.90	1.58	
19644, ...	34.00	0.15	Chiefly alcohol and water.
19637, ...	33.70	0.16	
19663, ...	33.20	0.22	Chiefly alcohol and water.
19653, ...	21.30	9.72	Acidity seven times normal.

Rum.

Inspector's Number.	Percentage of Alcohol by Weight.	Percentage of Extract.	Flavor, etc.
STANDARD,	42		
19668,	42.9	3.93	New rum.
19634,	42.4	0.10	New rum.
19602,	42.3	2.30	
19655,	42.2	2.00	
19662,	42.1	0.12	
19722,	42.0	0.11	
19777,	41.8	0.14	
19776,	41.4	0.40	
19673,	41.4	1.27	Chiefly brandy.
19621,	40.4	0.21	
19611,	40.4	0.10	
19677,	40.3	0.10	Flavored with acetic ether.
19738,	39.3	0.08	
19658,	38.7	0.07	
19771,	38.5	0.12	Chiefly whiskey, flavored with acetic ether.
19650,	38.5	1.45	
19658,	37.9	0.24	
19655,	37.4	0.06	
19772,	37.1	0.12	
19645,	36.7	0.62	
19651,	36.5	0.11	
19779,	36.4	1.01	
19638,	36.3	0.39	
19665,	36.0	0.84	
19668,	36.0	0.12	Acetic ether flavor.
19769,	36.0	0.12	
19676,	35.9	0.77	
19664,	35.0	0.49	
19767,	34.5	0.10	
19669,	34.5	0.09	
19783,	34.3	0.08	
19671,	34.0	0.07	
19641,	33.8	0.34	
19781,	33.3	0.04	
19643,	31.0	0.06	Practically alcohol and water.
19632,	30.8	0.61	Practically alcohol and water.
19624,	30.3	0.10	
19774,	29.8	0.07	
19647,	24.7	1.00	

Gin.

Inspector's Number.	Percentage of Alcohol by Weight.	Extract. Flavor, etc.
STANDARD,	40	
19740,	42.5	Slight lemon flavor.
19642,	42.5	
19674,	42.3	
19780,	42.0	
19720,	41.8	
19639,	41.8	4.6 per cent. extract; colored with caramel.
19607,	41.5	1.64 per cent. extract.
19613,	41.5	
19654,	41.5	
19660,	41.5	
19649,	41.0	
19646,	41.0	
19678,	40.8	
19642,	40.5	Colored.
19736,	39.3	
19618,	39.3	1.8 per cent. extract.
19640,	39.0	
19651,	39.0	

Inspector's Number.	Percentage of Alcohol by Weight.	Extract, Flavor, etc.
STANDARD,	40	
19723,	38.8	0.83 per cent. extract; malt odor.
19646,	38.7	
19659,	38.2	5.13 per cent. extract; coriander flavor.
19731,	37.2	0.5 per cent. extract.
19628,	37.1	Colored.
19650,	36.8	
19616,	35.5	
19657,	35.5	
19654,	34.0	
19644,	34.0	
19664,	32.8	
19666,	32.5	0.74 per cent. extract; malt odor.
19672,	31.6	
19670,	31.3	
19724,	29.5	Practically alcohol and water.
19625,*	33.9	1.23 per cent. extract; anise flavor.

* Kimmel.

"*Sweet*" *Cider.*

Inspector's Number.	Percentage of Alcohol by Weight.	Percentage of Acid calculated as Malic Acid.	Percentage of Extract.	Preservatives.
19818,	8.00	0.54	4.01	Absent.
19821,	6.93	0.63	3.36	Absent.
19822,	5.62	0.48	2.83	Absent.
19824,	5.37	0.54	2.42	Absent.
19823,	4.80	0.57	7.82	Absent.
19798,	3.55	0.72	4.73	Absent.

Pale Ale.

Inspector's Number.	Percentage of Original Wort Extract.	Percentage of Alcohol by Weight.	Percentage of Extract.	Preservatives.
19804,	15.99	5.37	5.15	Salicylic acid.
19807,	15.97	5.25	5.47	Absent.
19805,	14.02	4.62	4.78	Salicylic acid.
19803,	13.20	4.33	4.54	Salicylic acid.
19808,	13.15	4.25	4.65	Absent.
19806,	11.64	4.13	3.38	Absent.
19809,	10.95	3.53	3.79	Absent.

Beer.

Inspector's Number.	Percentage of Original Wort Extract.	Percentage of Alcohol by Weight.	Percentage of Extract.	Preservatives, etc.
19812,	18.91	7.07	4.77	Absent.
19819,	16.31	3.88	8.53	Salicylic acid.
19865,	16.26	4.25	7.76	Absent.
19862,	16.09	5.06	5.97	Absent.
19811,	15.98	5.31	5.36	Salicylic acid and fusel oil.
19866,	15.87	4.44	6.99	Salicylic acid.
19864,	15.60	4.00	7.60	Absent.
19810,	15.35	5.12	5.11	Salicylic acid.
19815,	15.01	4.58	5.80	Absent.
19813,	14.79	5.56	3.67	No preservative; fusel oil present.
19820,	14.48	4.19	6.10	Salicylic acid.
19814,	14.47	4.00	6.47	Absent.
19863,	13.33	4.25	4.83	Absent.
19817,	12.78	3.98	4.82	Absent.
19861,	7.33	1.10	5.13	Absent.

It will be seen from the above figures that but little care is taken to prevent the further fermentation of a "sweet" cider, and that the resulting liquor sold under the name "sweet" contains rather more alcohol than the average beer. The practice of checking fermentation by the use of salicylic acid has apparently not extended to cider.

Soda Water.

During the hot weather an enormous quantity of "soda water" is sold. It would seem a matter of some consequence that a fairly pure water should be universally used, and that it should not be contaminated by metallic poisons. It appears in some instances that a water is sold as "soda," which, if not charged with carbonic acid and flavored, would be recognized at once as distinctly unpalatable and unwholesome.

The following tables show the result of the examination of a number of samples of soda water bought by the glass from various soda fountains in and around Boston, and also of a number of flavoring syrups: —

Plain Soda Waters.

Inspector's Number.	Quality.	Inspector's Number.	Quality.
19785, . .	Good.	19794, . .	Contains a considerable trace of lead.
19790, . .	Good.	19795, . .	Solution of tartaric acid.
19791, . .	Contains a trace of lead.	19796, . .	A very hard water.
19792, . .	Good.	19797, . .	Contains a very large amount of iron.
19793, . .	Good.		

Soda Water Flavoring Syrups.

Inspector's Number.	Flavor.	Quality.
19786, ...	Vanilla, . . .	Good.
19787, ...	Strawberry, . .	Colored with cochineal and preserved with salicylic acid.
19788, ...	Lemon, . . .	Good.
19789, ...	Ginger, . . .	Good.
19799, ...	Orange, . . .	Colored with an aniline.
19800, ...	Lemon, . . .	Good.
19801, ...	Chocolate, . . .	Good.
19802, ...	Pineapple, . . .	Preserved with salicylic acid.

The traces of lead found in the soda waters may have originated in the tap water used, but it seems more likely that some lead was dissolved by the charged water from pipes, joints or fixtures connected with the soda tanks or fountain.

It will be seen that temperance drinks are liable to injurious contamination as well as liquors.

Drugs.

Of this class, 487 samples were examined; 163 proved to be not of standard quality.

Acidum Aceticum: 1 standard; 2 too weak.

Acidum Benzoicum: 8 samples, all standard.

Acidum Carbolicum: 1 standard; 1 inferior, containing too much water.

Acidum Hydrobromicum Dilutum: 3 standard; 1 too dilute.

Æther: 7 standard; 6 inferior, containing too much alcohol and water.

Alcohol: 9 standard.

Aqua Ammoniæ: 3 standard; 4 inferior, containing too little NH_3.

Aqua Chlori: 5, all of inferior strength; 2 containing no trace of chlorine.

Aqua Destillata: 2 standard; 10 inferior, containing considerable and in some cases very large amounts of organic and inorganic impurities. In some instances the town supply has been made to do duty as distilled water; but in others, where apparently a good quality of distilled water is kept, it has been sold in dirty bottles and consequently spoiled. One sample contained 122 parts of solid matter per 100,000.

Aqua Hydrogenii Dioxidi: 4 standard.

Arrow Root: 2 of good quality.

Bismuthi Subcarbonas: 1 standard.

Bismuthi Subnitras: 3 standard.

Calx Chlorata: 13, all containing too little available chlorine. The following brands were examined; several samples of one brand were found of very variable strength: "Brookmans," containing 12 to 30 per cent. chlorine; "Excelsior," containing 25 per cent. chlorine; "Hirschs," containing 25 per cent. chlorine; "Lion,"

containing 19 to 29 per cent. chlorine; "Red Cross," containing 28 per cent. chlorine. The Pharmacopœia calls for 35 per cent. of chlorine.

Cerii Oxalis: 6 standard.

Chloroformum: 6 standard; 5 inferior, containing too much alcohol.

Creta Præparata: 7 standard.

Extractum Glycyrrhizæ: 5 standard; 1 inferior, containing corn starch.

Ferri et Quininæ Citras: 7 standard; 2 inferior, containing too little quinine. The worst sample contained 90 per cent. of the required amount.

Glycerinum: 35 standard; 3 inferior, containing fats.

Glycyrrhizinum Ammoniatum: 1 standard.

Magnesii Citras: 1 standard.

Magnesii Sulphas: 8 standard.

Iodoformum: 6 standard.

Liquor Magnesii Citratis: 1 standard: 1 inferior, containing too little of the salt.

Lycopodium: 9 standard.

Oleum Amygdalæ Amaræ: 1 standard: 3 inferior, containing nitrobenzol.

Oleum Lavendulæ Florum: 8 standard; 1 inferior, containing turpentine.

Oleum Limonis: 6 standard; 1 inferior, containing turpentine.

Potassii Acetas: 4 standard.

Potassii Citras: 6 standard.

Potassii Iodidum: 6 standard.

Potassii Permanganas: 10 standard.

Pulvis Opii: 16 standard; 9 inferior, containing too little morphine.

Pulvis Rhei: 5 standard.

Quininæ sulphas: 8 standard.

Quininæ Bisulphas: 1 standard.

Spiritus Ætheris Compositus: 2 standard; 2 inferior, containing little or no ethereal oil.

Spiritus Frumenti: 2 standard; 4 inferior, containing too much extract and too little alcohol.

Spiritus Juniperi: 3 inferior, containing too much water.

Sulphur Sublimatum: 4 standard.

Syrupus: 2 standard; 1 inferior, containing too little sugar.

Tinctura Capsici: 1 standard.

Tinctura Iodi: 1 standard; 9 inferior, containing too little iodine.

Tinctura Nucis Vomicæ: 12 standard; 11 inferior, containing too little strychnine.

Tinctura Opii: 12 standard; 32 inferior, containing too little morphine. The morphine strength varied from 0.52 to 1.634 per cent.

Vinum Album: 1 standard; 8 inferior, containing too much sugar.

Vinum Rubrum: 13 inferior, containing too much extract.

Zinci Oxidum: 20 standard.

Miscellaneous.

Thirty-six standard, 12 inferior. In this class are included samples of "diamond face lotion," which contained 14.7 grains of corrosive sublimate per fluid ounce; and of "pure unfermented grape juice," some of which were found to be fermented (one containing as much as 8.07 per cent. of alcohol), some preserved

with boracic acid and some preserved with salicylic acid. A brand of "grape juice" specially recommended for invalids was found to be loaded with salicylic acid.

Samples of black stockings were found to contain much chromic acid.

A so-called "arsenic soap" for the complexion contained no trace of arsenic.

Summary.

	Genuine.	Adulterated.	Total.
Milk,	1,650	1,718	3,368
Food not milk,	2,566	270	2,836
Drugs,	324	163	487
Totals,	4,540	2,151	6,691

Respectfully submitted,

CHARLES P. WORCESTER.

PROFESSOR GOESSMANN'S REPORT.

Western Massachusetts.

The milk collected by the inspectors of the Board in the four western counties of Massachusetts has been examined during 1894, as in previous years, at Amherst. The whole number of samples examined was 183, and the ratio below the standard quality was 21.3 per cent., that of the preceding year having been 20.3.

The continuous inspection of milk from year to year in this part of the State has shown a uniformly higher quality in the milk offered for sale, as compared with that of eastern Massachusetts. As has been shown in previous reports, this difference is coincident with the difference in the density of population in these two districts. The rapid growth of cities, together with their outlying suburbs, has created a demand for milk which at times exceeds the supply. The occupation of new territory once occupied for the purposes of pasturage has driven the business of milk producing farther and farther away from the centres of population, and compelled the contractors and milk collectors to seek for supplies at increasing distances, and increased the difficulties of collection and diminished the facilities for rapid delivery of this important article of food. These changes have taken place much more rapidly in eastern than in western Massachusetts.

The following report embraces the samples of milk obtained during the year in cities and towns west of Worcester County : —

The results of analyses were as follows : —

Whole number examined,	183
Number above standard,	144
Number below standard,	39
Percentage below standard,	21.3
Samples of skimmed milk,	15

Chicopee.

Number of samples,	16
Number above standard,	15
Number below standard,	1
Percentage below standard,	6.2
Skimmed milk,	3

Holyoke.

Number of samples,	16
Number above standard,	11
Number below standard,	5
Percentage below standard,	31.2
Skimmed milk,	2

Northampton.

Number of samples,	16
Number above standard,	15
Number below standard,	1
Percentage below standard,	6.2
Skimmed milk,	2

Pittsfield.

Number of samples,	21
Number above standard,	13
Number below standard,	8
Percentage below standard,	38.1
Skimmed milk,	0

Springfield.

Number of samples,	55
Number above standard,	45
Number below standard,	10
Percentage below standard,	18.2
Skimmed milk,	6

The results in the towns were as follows: —

	Total.	Above Standard.	Below Standard.	Percentage below Standard.
Adams,	20	16	4	–
North Adams,	23	14	9	–
Ware,	16	15	1	–
	59	45	14	23.7

C. A. GOESSMANN.

REPORT UPON EXPERIMENTS

IN

FEEDING HOGS AT A STATE INSTITUTION

WHERE TRICHINOSIS AMONG THE SWINE HAD BEEN UNUSUALLY PREVALENT.

By Prof. E. L. MARK of Harvard University.

REPORT UPON EXPERIMENTS IN FEEDING HOGS AT A STATE INSTITUTION WHERE TRICHINOSIS AMONG THE SWINE HAD BEEN UNUSUALLY PREVALENT.

By Prof. E. L. MARK of Harvard University.

Dr. S. W. ABBOTT, *Secretary State Board of Health.*

DEAR SIR: — I herewith transmit my report on the result of examinations for trichinæ of hogs killed at the Northampton Lunatic Hospital during the ten years 1884–94 inclusive.

The results have been tabulated (Table I.) so as to show the number of hogs of each sex examined during each of the ten seasons and the number found to contain trichinæ in each case. The ratios between the number examined and the number found to be trichinous have been expressed in per cents. for each sex and for the two sexes taken together.

Table II. gives a detailed account of the twenty-five trichinous individuals killed during the seasons 1887–88 to 1893–94. The third, fourth and fifth columns are compiled from the information sent from the hospital, the age being given in months only. The sixth column shows the approximate date of birth, based on the two preceding columns. The seventh and eighth columns show the period — *computed to the nearest month only* — which elapsed between Jan. 1, 1887, and the time of birth, either before or after that date.

I. Table showing Reduction in the Proportion of Swine infected with Trichinæ at Northampton Lunatic Asylum following a Substitution of COOKED *for* UNCOOKED *Kitchen Offal, and the Exclusion of Slaughter-house Refuse. Period of Examination covers Ten Seasons. Change in Diet made Jan. 1, 1887.*

DATES.	MALES.			FEMALES.			TOTAL BOTH SEXES.		
	Number Examined.	Number Trichinous.	Per Cent. Trichinous.	Number Examined.	Number Trichinous.	Per Cent. Trichinous.	Number Examined.	Number Trichinous.	Per Cent. Trichinous.
1884-85,	11	6	54.5+	20	2	10.0	31	8	25.8+*
1885-86,	6	2	33.3+	10	8	80.0	16	10	62.5
1886-87,†	24	3	12.5	33	8	24.2+	57	11	19.3—
1887-88,	17	3	17.6+	26	3	11.5+	43‡	6	14.0—
1888-89,	23	3	13.0+	18	4	22.2+	41	7	17.1—
1889-90,	17	0	0.0	32	5	15.6+	49	5	10.2+
1890-91,	24	1	4.2—	44	3	6.8+	68§	4	5.9—
1891-92,	21	1	4.8—	33	1	3.0+	54	2	3.7+
1892-93,	10	0	0.0	27	1	3.7+	37‖	1	2.7+
1893-94,	23	0	0.0	30	0	0.0	53	0	0
	176	19	10.8—	273	35	12.5—	449	54	12.0+

* By a clerical error in report of April 10, 1893, this was made 22.2 per cent.

† No uncooked offal or viscera fed to hogs after Jan. 1, 1887.

‡ Ten hogs, all free, examined after the report April 16, 1888, were accidentally omitted in report April 10, 1893.

§ By an error in copying, the number reported April 10, 1893, was 64. The per cent. was correct.

‖ Three hogs, all free, examined after report April 10, 1893, are included here.

II. Table showing that of Twenty-five Trichinous Hogs slaughtered during Seven Seasons (1887–94) Ten were living in Northampton when Change of Regimen occurred, and Eight were old enough to have possibly acquired Trichinæ before that change.

SERIAL NUMBER 12000 +.	Number of Trichinæ Found.	Sex of Hog.	Date Killed.	Approximate Age.	Approximate Date of Birth.	BORN (APPROXIMATE). Before Jan. 1, 1887.	After Jan. 1, 1887.
				Yrs. Mos.		Yrs. Mos.	Yrs. Mos.
247,	21	Male.	Jan. 20, 1888.	0 11½	Feb. 5, 1887.	–	0 1
250,	3	Female.	Feb. 3, 1888.	0 11	Jan. 3, 1887.	–	0 0
251,	4	Male.	Feb. 3, 1888.	1 0	Feb. 3, 1887.	–	0 1
252,	16	Male.	Feb. 10, 1888.	1 2	Dec. 10, 1886.	0 1	
253,	3	Female.	Feb. 10, 1888.	1 2	Dec. 10, 1886.	0 1	–
254,	4	Female.	Feb. 17, 1888.	1 9	May 17, 1886.	0 6	
276,	10	Female.	Jan. 4, 1889.	3 0	Jan. 4, 1886.	1 0	–

II. Table showing that of Twenty-five Trichinous Hogs slaughtered during Seven Seasons (1887–94) Ten were living in Northampton when Change of Regimen occurred, and Eight were old enough to have possibly acquired Trichinæ before that change — Concluded.

SERIAL NUMBER 12000 +.	Number of Trichinæ Found.	Sex of Hog.	Date Killed.	Approximate Age.	Approximate Date of Birth.	BORN (APPROXIMATE). Before Jan. 1, 1887.	After Jan. 1, 1887.
				Yrs. Mos.		Yrs. Mos.	Yrs. Mos.
279, . . .	2	Male.	Jan. 10, 1889.	3 6	July 10, 1885.	1 6	–
282, . . .	3	Female.	Jan. 25, 1889.	3 6	July 25, 1885.	1 5	–
286, . . .	2	Male.	Feb. 8, 1889.	1 2	Dec. 8, 1887.	–	0 11
292, . . .	1	Male.	Mar. 1, 1889.	4 0	Mar. 1, 1885.	1 10	–
296, . . .	4	Female.	Mar. 15, 1889.	16 0† 1 4	Mar. 15, 1873. Nov. 15, 1887.	13 9? –	0 10?
301, . . .	6	Female.	Mar. 29, 1889.	3 0	Mar. 29, 1886.	0 8	–
333, . . .	9	Female.	Feb. 14, 1890.	3 0	Feb. 14, 1887.	–	0 9
334, . . .	14	Female.	Feb. 20, 1890.	3 0	Feb. 20, 1887.	1 10	–
336, . . .	3	Female.	Feb. 27, 1890.	3 0	Feb. 27, 1887.	–	0 2
339, . . .	7	Female.	Mar. 6, 1890.	5 0	Mar. 6, 1885.	–	0 2
344, . . .	2	Female.	Mar. 27, 1890.	2 6	Sept. 27, 1887.	–	0 1
374, . . .	2	Female.	Dec. 19, 1890.	1 6	June 19, 1889.	–	2 6
396,* . . .	2	Female.	Feb. 26, 1891.	3 0	Feb. 26, 1888.	–	1 2
415, . . .	15	Female.	Apr. 9, 1891.	1 8	Aug. 9, 1889.	–	2 7
420, . . .	2	Male.	Apr. 24, 1891.	1 10	June 24, 1889.	–	2 6
462, . . .	43	Female.	Feb. 18, 1892.	1 4	Oct. 18, 1890.	–	3 10
466, . . .	4	Male.	Feb. 25, 1892.	1 5	Sept. 25, 1890.	–	3 9
509, . . .	90	Female.	Mar. 3, 1893.	8 0	Mar. 3, 1885.	1 10	–

* Bred at Brattleboro', Vt., Asylum. All others bred at Northampton. All raised at Northampton.
† Record is "sixteen years;" perhaps it should be sixteen months.

The most significant fact shown by Table I. is the almost constant and regular reduction in the proportion of hogs found to be trichinous since 1887. Beginning with a high per cent. of infection, the reduction has progressed until at present the parasites seem to be absent.

The last trichinous hog examined was slaughtered March 3, 1893, — nearly two years ago; the hogs thus far examined for the season 1894–95 being, like all of those of the season 1893–94, free from trichina.

So far as is known the conditions to which the hogs were subjected before Jan. 1, 1887, have been altered in only two particulars. The practice of feeding the viscera of slaughtered animals was then discontinued, and since that date no uncooked offal from the kitchen has been fed to the hogs.

An examination of Table II. shows that the last hog found to be trichinous was one year, ten months old when the change in regimen was made, and it is entirely possible that its infection occurred before the change. The last infected hog, before this one, was killed Feb. 25, 1892, — nearly three years ago, — so that there are at least grounds for hoping that the parasite may have wholly disappeared.

The number of hogs slaughtered is too few — on an average only about forty-five a year — to render the experiment satisfactory, and yet it may not be without importance. If in a sufficient number of cases it could be shown, upon a larger scale and under differing external conditions, that a similar result follows a like practice, considerable advance would have been made toward answering the question, What ought to be done to check the spread and diminish the recurrence of trichina in swine ?

EDWARD L. MARK.

CAMBRIDGE, Jan. 28, 1895.

ON AN

EPIDEMIC OF TYPHOID FEVER IN MARLBOROUGH,

APPARENTLY

DUE TO INFECTED SKIMMED MILK.

[With One Plate.]

By WILLIAM T. SEDGWICK, Ph.D., Biologist of the Board.


STATE BOARD OF HEALTH
MAP OF
EPIDEMIC OF
TYPHOID FEVER
ROUTE OF SKIMMED-MILK WAGON
CASES OF TYPHOID FEVER.

ON AN EPIDEMIC OF TYPHOID FEVER IN MARLBOROUGH. APPARENTLY DUE TO INFECTED SKIMMED MILK.

[With One Plate.]

By WILLIAM T. SEDGWICK, Ph.D., Biologist of the Board.

On Sept. 7, 1894, I was informed by Dr. S. W. Abbott, Secretary of the Board, that an epidemic of typhoid fever had appeared in Marlborough, and, a request for aid having been received from Dr. W. S. Richardson, chairman of the Board of Health of Marlborough, I was instructed to make an investigation. On the same day I was requested by an official of another board to make an investigation of certain cases of typhoid fever in Fayville, a village in Southborough, which town adjoins Marlborough on the east and south. The next day, therefore, I went to Marlborough, calling at Fayville on the way, and offered my services on behalf of the State Board of Health to the Board of Health of Marlborough.

It appeared that about thirty cases of typhoid fever had already been reported and that, as is usual in such cases, various theories of the outbreak and its cause were held or suggested. The local papers contained numerous letters on the subject, some alleging that the water supply was infected, some that the sewerage was to blame, and some charging the trouble to accumulations of filth, such as dump heaps.

The first step taken under my advice was to examine the location of the cases, and for this purpose they were plotted on a map of the city. As a result it became clear, almost immediately, that the disease was restricted to the eastern half of the city, and also that there were in all at least forty cases. Having thus established the fact that the western portion of the city, which is quite densely populated and which includes "French hill," a district thickly settled by French Canadians, had been (up to that time) entirely free from typhoid fever, I was very soon enabled to assure the

water-works officials, who were in considerable anxiety and the subjects of much public criticism, that whatever the cause of the fever might be the water supply was plainly not at fault; for it was inconceivable that if it had been the disease should have appeared only in one portion of the city, and that the most remote from the distributing reservoir.

Considerations similar to those which enabled me to exclude the public water supply as the source of the epidemic made it easy to prove that the public sewers were not at fault, and the following editorial item in a local newspaper quickly served to allay the apprehensions of the public in these directions: —

Typhoid Fever. — Until the State Board of Health completes its study of the cases of this dangerous disease, the source of the trouble cannot be authoritatively announced. But we are warranted in saying that the cause is not in any way connected with either our water or sewer system. Our people need feel no uneasiness whatever relative to these.

It is a matter worthy of special note that it is thus sometimes possible within an hour after the arrival of a competent and experienced sanitary inspector to pronounce with absolute certainty that the public water supply or sewerage system cannot possibly be the source of the epidemic in question. As showing the possibilities of a rational and scientific epidemiology, it is interesting to observe that the conclusions here announced were reached and conveyed to the officials of the water and sewer departments after only a few hours of investigation. These officials expressed themselves as greatly relieved and highly gratified. It should not be overlooked, however, that the conditions for reaching such a conclusion quickly were here especially favorable. If the conditions had been exactly reversed and the cases, instead of being remote from the reservoir, had been near it (as might easily have happened), then it would have been impossible to say, from their location, that they were not due to the water supply. On the contrary, the suspicion that they were due to it must then have been strong because the absence of cases remote from the reservoir might have been accounted for by the death of the disease germs in the pipes. Fortunately, in the present case the disease was strictly confined to a region remote, relatively speaking, from the reservoir, and it was easy to show that, therefore, they could not have come from the water supply.

But while a very brief investigation had thus established the fact that the epidemic could not possibly be attributed to the public systems of water supply or sewerage, the true source of the outbreak still remained to be found, and I next turned to the milk supply as a possible vehicle of the disease. But it soon became plain that many different milkmen were involved, and that therefore ordinary milk could not have been the common carrier of the infection. Closer inquiry, however, finally disclosed the fact that very nearly in the middle of the infected district was a "creamery" which, although private, served in a manner as a milk centre for the whole city. More careful investigation revealed the following facts.

This creamery bought milk from twenty-eight different farms, which constituted its regular supply. It also bought, from time to time, from the various independent milk peddlers whatever milk they had left over and wished to sell after their daily rounds. On the other hand the creamery sold to the various milk peddlers whenever their own supplies "ran short," and in these ways served, as it were, as a kind of "clearing house" for the milk supply of Marlborough. From the milk which it purchased it made cream and butter, and the buttermilk and skimmed milk were sold. The butter had an excellent reputation, and was sold at such prices that it was said to go mostly to the well-to-do families of Marlborough.

It is important to observe that no "whole" milk (as fresh milk is called in contradistinction to "skimmed" milk) was sold by the creamery excepting uncertain amounts to peddlers who "ran short," as has already been stated. The skimmed milk produced, on the other hand, had to be disposed of, and for this purpose a special milk wagon was run, by the proprietor of the creamery, from which skimmed milk was peddled, daily, over a considerable section of the city. Moreover, this milk because of its cheapness was extensively purchased, being used chiefly perhaps for cooking, but, also, to a very considerable extent, for drinking purposes. Such milk either from the "separator" or skimmed after standing only a few hours in iced water is still sweet and palatable.

My suspicions at once rested, largely because of its central location among the cases, on the creamery, and very soon after upon this special skimmed-milk service. I therefore made in the next place a house-to-house investigation which established, beyond all possible doubt, the fact that here was a common bond existing between most of the cases. It had not escaped observation that the disease

was confined to those of slender means or in poor circumstances, and closer investigation showed that some who had attempted to economize in their milk supply by using skimmed milk had suffered most severely. One case in particular may be mentioned. A widow of very small means was supporting a family of four children aged seventeen, thirteen, eight and five years, respectively. For the sake of economy she purchased no milk excepting skimmed milk, and that from the "creamery" wagon. At the time of my visit three of the children were abed with typhoid fever and the fourth was apparently in the prodromal stage as a secondary case.

In the house-to-house investigation much skill and tact were necessary, in some cases, to secure any admission that skimmed milk had been bought and, especially, that it had been much used for *drinking* as well as for cooking. In a few cases it was persistently denied that it had ever been so used. This was probably not always true, but even if it were true the confusion of dishes in a kitchen might easily lead to exchange and the accidental use of skimmed milk. The only reason for evasion or concealment of the facts was the dislike to confess that so despised an article of food as skimmed milk had been used.

The total number of cases during the epidemic period (August 1 to September 15) was 50. Of these 1 was imported from Fayville, leaving 49 to be accounted for. The total number of those known to have had access to skimmed milk, buttermilk or cream from the creamery, was 47. The number who bought milk of a milkman known to deal with the creamery, but not otherwise connected, was 2, — making altogether 49 (or the whole number of cases) who might have been infected from this source. Of the 47 who had access to skimmed milk, buttermilk or cream, direct from the creamery, 45 had access to skimmed milk, 1 to buttermilk and 1 to cream.

On the 15th of September I had progressed far enough to make the following report: —

To Dr. Wm. S. Richardson, *Chairman, Board of Health of Marlborough.*

Dear Sir: — I have now completed, on behalf of the State Board of Health, a preliminary investigation of the recent outbreak of typhoid fever in Marlborough with the following result: I find that there have been in all, thus far, 50 cases in the city, of which 49 appeared to have originated here and one has been imported. The disease has been confined to the eastern portion of the city, a considerable area on the west having had no cases. For this reason it is impossible to suppose that any general contamination

of the public water supply has occurred which might explain the present outbreak, and I find no evidence of any kind which would throw suspicion, in this connection, upon the city water. Nor is there any reason to attribute the disease to sewerage, for the houses affected do not differ essentially in their sewerage from many other houses having no fever in them, while a considerable section of the city though similarly sewered has had no typhoid fever cases.

Inasmuch as it is well known that unboiled milk is a ready vehicle of typhoid fever, I turned next to a consideration of the milk supply of those affected, and was rewarded by the discovery that a very large number of them had been supplied with, or had had access to, milk from a common source. I have therefore made a thorough study of the milk supply of the city, and as a result have been forced to conclude that the recent outbreak of typhoid fever in Marlborough was caused by milk, and mostly by skimmed milk, which had for the time being become contaminated, in some way at present unknown. The attack was most severe during the last week in August and now appears to have nearly subsided. Epidemics due to infected milk are not uncommon, but all danger from typhoid fever in milk may be averted by using only milk that has been heated to the boiling point.

Very respectfully yours,

W. T. SEDGWICK,

Biologist, State Board of Health

In cases of this kind a general anxiety often prevails which causes the people to turn upon the local authorities, such as the board of health, the sewer commissioners and especially the water board, alleging their incompetency or neglect and demanding their removal from office. At such times it is of the highest importance to have some outside and, if possible, superior, disinterested and unprejudiced authority assume the burden of investigation, and without suspicion of fear or favor examine into the facts.

The following comment from a local paper illustrates these points: —

Typhoid Fever. — The emphatic decision of the State Board of Health in favor of our water and sewer systems will, we trust, relieve the unduly weighted minds of those who so recently have been busily endeavoring to discredit them. Milk is a very common source of disease, and it is not at all surprising that it should have caused the trouble here. Rather, it is gratifying to know that the disease is confined to a food that can readily be dispensed with for a time, and can be made perfectly safe by boiling. The city is doubly fortunate in the character of the trouble, the few deaths therefrom, and the prompt and decisive action of the health authorities.

To discover the close coincidence between the skimmed-milk route and the location of the cases reference may be had to the accompanying plate. Some of the cases near the "creamery" bought not from the wagon but directly from the creamery itself. Those on Monument Avenue and Windsor Street bought skimmed milk which had come from the creamery but not from the regular wagon. The case on Mechanic Street came from the same source as these. The cases on Frye and Wachusett streets bought buttermilk and milk from a man who had some dealings with the creamery. The same is true of the case on Liberty Street. One or two of the remaining cases were imported. That on Beach Street came from Fayville.

Enough has now been said to show that the creamery was apparently the source of the epidemic. The location of the creamery (on the corner of Maple and East Main streets) is shown on the map.

It will be observed that there was a case of typhoid fever in this creamery. I was early informed of this fact, but was assured that the patient (J. H. P.) was merely a partaker in the common misfortune. Mindful of the milk epidemic of typhoid fever in Somerville (see Report of 1892), in which the driver of one of the milk wagons appeared to be only a partaker, but was afterward found to have been the probable cause of the common disease, I examined this case with special care, particularly after it had become evident on careful investigation that no typhoid fever existed on any of the farms regularly tributary to the creamery. The matter became still more important when I discovered that the case in the creamery was that of *the driver of the skimmed-milk wagon*, although he had only taken to his bed on August 28, namely, after the height of the epidemic had been reached.

To show, however, that J. H. P. was really attacked early enough to have been possibly the unconscious cause of the whole trouble it is only necessary to cite the following facts: While it is true that he took to his bed on the 28th of August, and called on that day the physician who attended him throughout his illness, the young man himself states that he had had considerable fever and had been really ill for eleven days before this time; and it is a matter of record that six days before he gave up, namely, on the 22d, he was so ill that he almost fainted in church; while a trustworthy physician whom he consulted found that he had on that day a temperature of 103° F. Again, when I first saw him on September 14 he was dressed and

sitting up in obvious convalescence; and soon after he began regular work again at another place. If he had really been a patient dating from August 28 he would then have been in his third week; whereas he was clearly far beyond this point. In my judgment, and in that of Dr. Richardson, this young man may have had typhoid fever at a date early enough to have been the cause of the entire epidemic.

To show his precise relation to the milk, and how he might have infected it, a brief account must be given of the business of the creamery. It appears that the farmers brought in the greater part of the supply before 8.30 A.M. daily. Some of this milk was "set" in deep cans standing in cold water in large wooden chests. The creamery was rather old-fashioned, having none of the modern "Cooley" creamers, and buying milk instead of cream. About one-fifth of the whole product was "set" in this way, for the sake of the cream, which, thus "raised," is preferred by some consumers to that from the "separator." The rest of the milk went into a tank holding perhaps one hundred and fifty gallons; and from this very soon into the separator. The milk that was set was skimmed by hand very early next day (in this case by the wife of the proprietor of the creamery). There were thus, in the forenoon, two kinds of "skimmed" milk; one nearly twenty-four hours old and known as "*hand skum*" (hand skimmed); the other comparatively fresh and recently from the separator. The force at this creamery consisted of the proprietor and his son (a youth), his wife and J. H. P., the young man who had typhoid fever. J. H. P. had nothing whatever to do with the "whole" milk (fresh milk) or with the butter or the cream. His duty was to rise early, breakfast, fill his own milk cans and peddle the skimmed milk. Occasionally he carried buttermilk and cream, also. It was his custom to pour the skimmed milk first from the "hand-skimmed" cans; and this usually more than sufficed for his first wagon load. When this was sold he returned and took a second load, either of similar skimmed milk or of that, by this time, of the same forenoon, perhaps now ready from the separator. With this he supplied the north-eastern part of his route. A third load went to the north-western and western part of the city; and this was oftenest a load of the separator-skimmed milk. The first load went mostly to the southern part of the city, and on this route the largest number of cases appeared. Whether the "hand-skimmed" milk was really worse and the "separated" milk was less infected, it is impossible to say; but J. H. P. stated that the

cleanest skimmed milk was that from the separator. After delivering the three loads of milk J. H. P. was accustomed to have his dinner, wash his cans, sweep, and clean up and make himself generally useful.

I find no evidence that either the whole milk or the butter was infected at any time, and no good evidence that any cream or buttermilk was infected. The skimmed milk, however, appears to have been all infected, inasmuch as that sold occasionally in small quantities by another wagon appears to have caused typhoid fever as readily as that sold by J. H. P. The "whole" milk may possibly have been infected; but in the entire absence of any evidence of such infection it is more reasonable to suppose that J. H. P., whose duty was wholly confined to the skimmed-milk service, somehow contaminated the latter supply. I have shown in the Report of the State Board of Health for 1892, in connection with the Somerville epidemic, how infection may easily enter milk from the hands of a person "handling" it, if that person is at the time suffering from typhoid fever and is not more than ordinarily careful as to personal cleanliness; and it is my belief that J. H. P. was in some such way the original source of the epidemic in Marlborough.

The epidemic in Springfield in August, 1892, was closely connected with and, in one sense came through, a creamery. This case is fully discussed in the report for 1892. In the *Lancet* for April 21, 1894, is a lengthy and valuable article entitled "Creameries and Infectious Diseases." In this the author (Dr. J. J. Welply) gives an account of an epidemic of typhoid fever in which an outbreak of 61 cases was traced by him to a creamery. Of the 61 cases 52 contracted the disease directly through the creamery and mostly by drinking "separated" (skimmed) milk. In this case, also, no evidence was found that the butter was infected, and as far as I know we have yet to obtain satisfactory evidence of typhoid fever conveyed by butter, although doubtless some apparently "original" sporadic cases find their explanation here.

The cases in Fayville on investigation seemed to belong with those in Marlborough in incidence and origin; and although it was not positively proved that any of the skimmed milk had reached the cheap boarding-houses for laborers in which the typhoid fever in Fayville occurred, it is known that the keepers of these boarding-houses used much cheap milk, that they bought many of their supplies in Marlborough and that they might easily have bought

skimmed milk there. The cases in Fayville ceased as soon as adequate disinfection was instituted.

The epidemic in Marlborough ended on September 12. No more cases occurred, so far as is known, in this month, excepting one on the 18th, one on the 25th and one on the 29th. In October, however, 20 more cases are recorded, but of the existence of these I was not informed until long afterwards, when a careful study showed them to be mostly secondary cases, or else cases tardily reported and really belonging in the earlier group. The total number of deaths from typhoid fever in Marlborough in 1894 was 9, of which 7 may be attributed to the epidemic.

For aid in studying the later cases, and for the making of the plate which accompanies this paper, I am indebted to Mr. R. D. Chase, S. B. Dr. W. S. Richardson, chairman, and Mr. D. S. Callahan, agent, of the board of health of Marlborough are also entitled to honorable mention for much valuable assistance rendered.

The following brief account of the epidemic is taken from the annual report of the board of health of Marlborough for 1894: —

During the last week in August the board of health ascertained that there were in the city 12 probable cases of typhoid fever. As so large a number of cases had not appeared in the city at any time during the last ten years, the board thought that the cause must come from a common source, and immediately solicited the aid of the State Board of Health in investigating what seemed to be the beginning of an epidemic. In a few days Professor Sedgwick, Biologist of the State Board, who has had large experience in work of this kind, came and began the task of discovering the probable location of the cause of the disease. . . .

Attention was first directed to Marlborough's water supply. The number of cases had now increased to 35. On a map of the city the location of these cases was indicated by a colored crayon. A glance at this map showed that the disease existed only in a limited area in the eastern part of the city. This fact proved conclusively that the germs of the disease could not be present in the entire water supply of the city. In places where epidemics have been found to be spread through the medium of the water supply the part of the town suffering most has been that nearest the source of that water supply. At this time there was not a single case of fever in the western part of the city where the water from the reservoir is first distributed.

Other possible water supplies to the infected part of the city were next considered, and then the food and milk supply. It was found that all the families where cases of typhoid existed had access to one milk supply.

The time of the first appearance of the disease in the city was next investigated. The time that the patients went to bed and the dates of appearance of the first symptoms of reported cases were made note of. These notes disclosed the fact that one patient might have been the innocent cause of the epidemic. Through this patient the milk supply for a part of the city might have become infected for a certain time. The further history of the epidemic went to prove that this was its probable origin; for after the patients who might have contracted the disease from this source had recovered, the epidemic was practically at an end and only scattering cases appeared later. . . .

Some member of the board or its agent visited all of the infected houses, and wherever disinfection could not be properly carried out because of lack of means the board furnished aid and assistance. The board of health of Marlborough, in behalf of the citizens and for themselves, are most thankful to the State Board of Health for this investigation. It was carefully and rapidly made by one thoroughly familiar with this kind of scientific work, and the conclusions arrived at dispelled the fears of danger from the water supply and certain other possible sources of contagion.

As far as I know the present is the first case on record in America in which an epidemic of typhoid fever has been apparently due to the use of infected skimmed milk; but it is easy to believe that many obscure outbreaks of this disease may have come from a similar source. With the multiplication of creameries to which milk (or cream) is brought from numerous and various farms, the possibility must be kept in mind of contamination of the whole product by one infected contributory portion; and inasmuch as skimmed or "separated" milk, on account of its cheapness and freshness, is now much used not only for cooking but also for drinking, this product, as well as the "whole" milk, must henceforward be regarded as a possible vehicle of infectious disease.

STATISTICAL SUMMARIES

OF

DISEASE AND MORTALITY.

STATISTICS OF DISEASE AND MORTALITY.

For more than twenty years the Board has collected and published statistics of mortality from cities and towns in the State which have voluntarily contributed them for compilation. The labor of this useful department has been increased from time to time by the enactment of new statutes, making the collection of certain statistics compulsory, so that the following lines of statistical work are now conducted in the general department of the Board : —

1. The collection and publication of the weekly returns of deaths contributed mainly by the city registrars and boards of health of the cities and large towns. These are published in the form of a weekly bulletin, one copy of which is sent to the registering officer of each city and town in the State weekly. During the past year the cost of issuing this report has been considerably diminished by the decision of the postal authorities to the effect that the bulletin may be sent through the mails as second-class matter.

2. The publication of the numbers of cases and deaths from each one of four principal infectious diseases occurring in each city and town whose annual reports are forwarded to the office of the State Board of Health, the diseases included being diphtheria, scarlet fever, typhoid fever and measles, these being the four infectious diseases which are most commonly reported to local boards of health by physicians. By comparing the deaths with the reported cases the mean ratio of fatality from each for a series of years is obtained with a fair degree of accuracy.

3. In consequence of a statute enacted in 1893 (chapter 302), entitled "An act relative to notices from local boards of health in cases of diseases dangerous to the public health," it has now become possible to collect and publish with greater certainty such information as is required by the statute in regard to the prevalence of infectious diseases in the State. By the terms of this act every local board of health which has had notice of the occurrence of a case of small-pox or of any other disease dangerous to the public health is required to report the same to the State Board of Health within twenty-four hours after receipt of each such notice.

In this act no "disease dangerous to public health" was specified

by name except small-pox. The Board, therefore, deemed it proper, in consequence of the doubt which might arise among local boards as to the interpretation of this clause, to express its opinion upon the question as to what diseases should be deemed subject to official notice under the term "dangerous to public health." The diseases which the Board considered as coming within the meaning of the act in addition to *small-pox* are: *scarlet fever*, *measles*, *typhoid fever*, *diphtheria*, *membranous croup*, *cholera*, *yellow fever*, *typhus fever*, *cerebro-spinal meningitis*, *hydrophobia*, *malignant pustule*, *leprosy and trichinosis.*

The Board issued a circular upon this subject in September, 1893, calling the attention of local boards of health to the new law; and consequently the first report under that act comprised the returns of the closing months of 1893. To this is added in the present report a summary of the returns under the same act for 1894.

4. In the following year, 1894, another act was passed, pertaining to the election of boards of health in towns, which contained the following section relating to certain returns to be made to the State Board of Health: —

[Acts of 1894, Chapter 218, Section 3.]

In each city and town having a population of more than five thousand inhabitants, as determined by the last census, at least one member of said board shall be a physician, and the board shall send an annual report of the deaths in such town to the State Board of Health. The form of such reports shall be prescribed and furnished by the State Board of Health.

The first returns made under the provisions of this act are summarized in the following pages.

Of these four lines of statistical work the two latter are the result of acts of the Legislatures of 1893 and 1894. Each has its value: the first consists of the weekly mortality returns, being useful in determining the seasonal mortality by weeks from several infectious and other diseases for each year and for a series of years; the second presents the ratio of fatality (percentage of deaths to cases) from diphtheria, scarlet fever, typhoid fever and measles; the third shows the number of reported cases of certain diseases "dangerous to the public health" in each of the cities and towns which complied with the statutes (chapter 302, Acts of 1893) during the year; and the fourth presents a general report of the mortality during the year 1894 in cities and towns having a population over 5,000, summarized and classified according to sexes, age and season of the year.

I.

SUMMARY OF THE WEEKLY MORTALITY REPORTS FROM CITIES AND TOWNS.

The following summary comprises the returns of deaths made at the end of each week by the town clerks, city registrars and other officials having in charge the vital statistics of cities and towns.

These returns are compiled each week and published as a bulletin, one copy of which is sent to the registering officer of each city and town in the State. These reports are necessarily incomplete, since they are voluntary, and comprise the mortality statistics of a part of the population only, the reporting places being chiefly the cities and larger towns. The estimated population of the cities and towns contributing to the returns of 1894 was about 1,466,000, or about three-fifths of the total population.

The data embraced in this summary are the following: —

Average height of barometer for each week.
Mean maximum temperature.
Mean minimum temperature.
Rainfall expressed in inches.
Total deaths reported for each week.
Deaths of children under five years.
Deaths from infectious diseases.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diarrhœal diseases.
Deaths from scarlet fever.
Deaths from measles.
Deaths from diphtheria and croup.
Deaths from puerperal fever.
Deaths from whooping-cough.
Deaths from malarial fever.
Deaths from small-pox.
Deaths from erysipelas.

The following table contains a summary of the statistics compiled from these weekly returns of mortality: —

Summary.

Date.	Barometer.	Minimum Thermometer. Mean for each Week.	Maximum Thermometer. Mean for each Week.	Rain. Inches per Month.	Humidity.	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diphtheria and Croup.	Scarlet Fever.	Measles.	Diarrhœal Diseases.	Whooping-cough.	Malarial Fever.	Small-pox.	Puerperal Fever.	Erysipelas.
Jan. 6,	30.08	27	34	-	79	671	168	71	156	4	22	13	1	9	2	-	-	1	-
13,	30.03	17	30	-	67	649	183	66	183	7	27	13	1	5	3	-	2	1	2
20,	30.35	24	37	-	70	574	174	75	133	6	33	15	1	10	3	-	5	-	4
27,	30.25	25	38	3.30	73	571	156	72	133	2	23	11	2	7	5	-	-	1	3
Feb. 3,	29.91	21	35	-	69	558	143	61	119	6	29	8	1	2	5	-	1	1	2
10,	30.06	25	38	-	73	532	150	57	110	7	18	14	-	5	4	-	-	2	1
17,	30.17	14	31	-	77	539	152	77	110	5	20	16	-	7	5	-	-	4	2
24,	30.17	22	34	3.21	62	591	182	78	100	9	18	8	4	7	4	1	1	4	2
March 3,	30.25	23	39	-	65	529	157	68	101	-	27	7	2	7	1	-	4	1	3
10,	30.21	39	54	-	71	579	197	77	112	5	20	5	3	6	3	-	2	2	2
17,	29.95	35	50	-	72	503	162	64	103	6	16	10	1	11	3	-	-	2	1
24,	30.05	38	52	-	71	562	191	86	102	3	21	9	2	8	5	-	4	1	5
31,	30.08	29	43	1.29	60	454	152	55	97	7	14	5	-	8	4	1	1	-	2
April 7,	29.99	35	49	-	63	521	156	59	84	6	19	9	1	4	1	1	2	1	3
14,	30.00	33	39	-	83	503	166	56	88	2	19	7	1	6	6	-	3	-	-
21,	30.11	45	56	-	69	502	162	67	96	3	16	19	1	4	7	-	1	-	1
28,	29.97	47	67	2.88	64	461	137	58	81	8	14	5	-	6	5	-	1	1	1
May 5,	30.13	49	66	-	64	530	185	58	72	9	27	7	3	6	8	1	1	1	1
12,	30.05	62	71	-	62	474	154	48	82	4	27	7	1	7	2	-	-	1	-
19,	29.90	49	56	-	60	498	170	55	79	8	14	11	-	7	4	-	-	-	2
26,	29.99	45	57	3.84	84	508	161	58	58	4	27	18	2	6	9	2	-	3	4
June 2,	29.86	51	65	-	76	473	126	59	61	2	19	16	2	10	6	1	-	-	1
9,	29.85	53	70	-	55	455	120	56	50	3	21	9	-	8	2	1	-	1	2
16,	30.07	71	81	-	69	472	158	47	50	4	12	19	2	17	7	-	-	1	1
23,	29.98	68	88	-	71	559	206	69	53	2	21	14	1	31	10	-	-	-	-
30,	30.07	62	76	1.22	85	474	167	70	30	2	17	7	1	45	7	-	-	1	-
July 7,	29.89	65	85	-	65	529	218	55	30	4	9	7	2	90	4	-	-	-	1
14,	29.96	63	79	-	59	624	280	69	20	2	13	9	-	161	5	-	-	-	1
21,	30.01	65	81	-	80	763	431	61	36	4	15	10	-	250	9	-	-	-	-
28,	30.00	65	81	2.32	77	741	429	59	22	6	18	6	1	268	6	-	-	-	1
Aug. 4,	29.96	67	81	-	70	724	407	58	25	8	22	6	-	239	8	-	-	-	1
11,	30.06	60	80	-	63	564	280	51	35	9	9	7	-	151	17	-	-	-	-
18,	30.02	61	72	-	80	544	271	50	23	2	18	6	-	100	11	-	-	-	-
25,	29.99	71	81	1.62	68	615	259	70	25	8	21	9	-	125	12	-	-	-	1

Sept. 1,	30.03	57	70	-	77	506	222	58	29	11	33	6	-	93	8	3	-	3	1
8,	30.13	61	76	-	71	558	246	57	28	14	18	7	-	75	8	-	-	2	-
15,	30.19	58	75	-	73	597	267	58	37	22	21	4	-	80	7	3	-	2	-
22,	30.02	60	71	-	95	589	240	65	33	21	20	7	-	97	6	-	-	-	-
29,	30.17	52	72	3.23	73	583	242	51	29	15	37	6	-	97	4	1	-	-	1
Oct. 6,	29.92	53	63	-	74	552	226	57	45	16	40	9	-	70	3	1	-	-	1
13,	29.97	48	64	-	71	531	183	45	44	20	47	3	-	69	1	1	-	1	-
20,	29.89	44	63	-	64	512	182	62	37	10	47	7	-	40	1	1	-	-	-
27,	30.19	46	53	5.37	86	542	189	56	46	15	38	7	-	48	4	1	-	-	-
Nov. 3,	30.05	46	59	-	79	500	180	53	57	14	49	3	-	12	2	-	-	1	-
10,	29.88	31	43	-	78	507	177	50	58	18	42	8	1	27	6	1	-	-	2
17,	30.03	33	46	-	70	484	134	55	57	15	35	9	1	5	2	-	-	3	1
24,	30.17	31	45	3.69	71	560	156	57	60	13	56	8	1	8	5	2	-	-	1
Dec. 1,	30.18	23	35	-	66	559	167	69	77	14	75	6	3	8	3	-	-	1	1
8,	30.09	27	39	-	74	524	176	65	71	9	63	9	-	8	9	-	-	2	1
15,	30.07	30	43	-	83	524	153	56	70	7	40	12	-	7	4	-	-	-	2
22,	30.18	32	47	-	64	503	162	54	58	12	34	12	-	9	6	-	-	2	3
29,	30.12	16	29	4.33	66	523	146	71	68	6	38	6	-	9	-	-	-	-	1
Totals,	-	-	-	36.30	-	28,440	10,258	3,179	3,563	419	1,397	471	40	2,395	282	22	28	47	65
Weekly averages,	-	-	-	.70	-	546	197	61	68	8	27	9	.77	46	5	.4	.54	.9	1.25
Rate per 1,000 deaths,	-	-	-	-	-	-	360.7	111.8	125.3	14.7	49.1	16.5	1.41	84.2	9.92	.77	.98	1.65	2.28
Rate per 1,000 population,	-	-	-	-	-	19.4	7.00	2.17	2.43	.29	.95	.32	.027	1.63	.19	.015	.019	.032	.044

Average reporting population, ... 1,466,000

Total Deaths.

The whole number of deaths reported for the year 1894 from the cities and towns contributing to these reports was 28,440 and the average number per week was 546. The greatest number of deaths reported in a single week was 763, in the week ending July 21; and the least number was 454, in the week ending March 31. The weekly average number of deaths reported for each month was as follows: —

January,	616	July,	664
February,	555	August,	612
March,	525	September,	566
April,	497	October,	534
May,	502	November,	498
June,	486	December,	527

The months in which the greatest mortality was reported were July, September and December, and those in which there was the least reported mortality were April, May and November. The percentages of mortality in each of the four quarters of the year were as follows: —

	All Ages.		Ages Under Five Years.	
	Numbers.	Percentages.	Numbers.	Percentages.
First quarter,	7,312	25.71	2,167	21.13
Second quarter,	6,430	22.61	2,068	20.16
Third quarter,	7,937	27.91	3,792	36.96
Fourth quarter,	6,761	23.77	2,231	21.75
	28,440	100.00	10,258	100.00

The death rate of reporting cities and towns was 19.4 per 1,000, the estimated population being 1,466,000.

Deaths under Five Years.

The reported number of deaths of children under five years of age was 10,258, and the average weekly number was 197. The greatest number reported in one week was 431, in the week ending July 21; and the least number was 120, in the week ending June 9. The ratio of the deaths of this class to the total reported mortality was

36.1 per cent., which was slightly greater than that of the preceding year (35.5 per cent.). The average weekly number of deaths of children under 5 years of age by months was as follows: —

January,	170	July,	339
February,	157	August,	304
March,	172	September,	243
April,	150	October,	195
May,	168	November,	162
June,	155	December,	161

The months having the greatest number of deaths of children under five years of age were July, August and September, and these having the least number were February, April and November.

Consumption.

The number of reported deaths from consumption was 3,179 and the weekly average was 61. The greatest number of deaths reported from this cause in a single week was 86, in the week ending March 24; and the least number was 45, in the week ending October 13. The average weekly number of reported deaths from this cause in each month was as follows: —

January,	71	July,	61
February,	68	August,	57
March,	70	September,	58
April,	60	October,	55
May,	54	November,	54
June,	60	December,	63

The months having the greatest number of deaths from this cause were March and December, and those having the least number were May and November. The following table presents the variations from the weekly average number of deaths from this cause for the past five years: —

	1890.	1891.	1892.	1893.	1894.		1890.	1891.	1892.	1893.	1894.
January,	+42	+4	+13	+8	+10	July,	−8	−4	−3	−7	0
February,	+3	−4	−8	−3	+7	August,	−4	−3	−4	−1	−4
March,	+3	−5	−1	+9	+9	September,	−5	−3	−11	−1	−3
April,	+1	+4	+7	+13	−1	October,	−11	+3	−5	−10	−6
May,	+1	+6	0	+1	−7	November,	−12	−4	−4	+2	−7
June,	−3	−2	−5	−9	−1	December,	0	+5	−1	−6	+2

The ratio of reported deaths from consumption to the mortality reported from all causes was 111.8 per 1,000, while that of previous years was as follows: —

1887,	141.1	1891,	116.5
1888,	134.2	1892,	111.3
1889,	125.0	1893,	106.5
1890,	130.0	1894,	111.8

The ratio to the estimated living population in 1894 was 2.17 per 1,000, as compared with 2.20 in 1893.

Acute Lung Diseases.

The number of reported deaths from acute lung diseases (bronchitis, pneumonia, pleurisy and asthma) during the year was 3,563 and the weekly average was 68. The greatest number of deaths reported from this group of causes in a single week was 183, in the week ending January 13; and the least number was 20, in the week ending July 14. The average weekly number of reported deaths from these causes for each month was as follows: —

January,	151	July,	27
February,	109	August,	27
March,	103	September,	31
April,	87	October,	43
May,	75	November,	58
June,	49	December,	69

The months having the greatest number of reported deaths from these causes were January and March, and those having the least number were July and August. The ratio of reported deaths from acute lung diseases to the reported mortality from all causes was 125.2 per 1,000. The estimated death rate per 1,000 of the reporting population from these causes was 2.42, as compared with 3.07 for the previous year.

Typhoid Fever.

The total number of reported deaths from this cause in 1894 was 419 and the average weekly number was 8. The greatest number reported in any single week from this cause was 22, in the week ending September 15; and there were no deaths reported for the week ending March 3. The average weekly number of deaths reported from this cause for each month was as follows: —

January,	5	July,	4
February,	7	August,	7
March,	4	September,	16
April,	5	October,	15
May,	6	November,	15
June,	2	December,	9

The months having the least number of deaths from this cause were April, June and July, and those having the greatest number were September, October and November. The ratio of reported deaths from typhoid fever to the reported mortality from all causes was 14.7 per 1,000, and the ratio to the reporting population was .28 per 1,000, as compared with .29 in the previous year.

Diphtheria and Croup.

The total number of reported deaths from diphtheria and croup in 1894 was 1,397 and the average number in each week was 27. The greatest number reported in a single week from these combined causes was 75, in the week ending December 1; and the least number was 9, in the week ending July 7. The average weekly number of reported deaths from these causes for each month was as follows: —

January,	26	July,	14
February,	21	August,	17
March,	20	September,	26
April,	17	October,	43
May,	24	November,	38
June,	18	December,	50

The months having the greatest number of reported deaths from these causes were October, November and December, and those having the least number were April, July and August. The ratio of deaths from diphtheria and croup to the reported mortality from all causes was 49.12 per 1,000, and the death rate of the reporting population was .95 per 1,000, that of the previous year being .69.

Scarlet Fever.

The reported deaths from scarlet fever in 1894 were 471 and the average weekly number was 9. The greatest number of reported deaths from this cause in a single week was 19, in the week ending April 21; and the least number reported in a single week was 3, in the week ending October 13. The average weekly number reported in each month was as follows: —

January,	13	July,	8
February,	11	August,	7
March,	7	September,	6
April,	10	October,	7
May,	11	November,	7
June,	11	December,	9

The months having the greatest number of deaths from this cause were January and February, and those having the least number were August and September. The ratio of deaths from this cause to the reported deaths from all causes was 16.56 per 1,000, and the death rate of reporting population from this cause was .32 per 1,000, that of the previous year being .36.

Measles.

The total number of reported deaths from measles in 1894 was 40 and the weekly average .77. The greatest number in a single week was 4. There were twenty-seven weeks in which no deaths from measles were reported. The average weekly number reported in each month was as follows: —

January,	1	July,	1
February,	1	August,	0
March,	2	September,	0
April,	1	October,	0
May,	1	November,	1
June,	1	December,	1

The ratio of deaths to the reporting mortality from all causes was 1.41 per 1,000, and the death rate from this cause was .027 per 1,000 of the reported living population, as compared with .06 in 1893.

Diarrhœal Diseases.

The diseases in this group are diarrhœa, dysentery, cholera morbus and cholera infantum. From these causes combined the number of deaths reported in 1894 was 2,395 and the weekly average number was 46. The greatest number reported in a single week was 268, in the week ending July 28; and the least number was 2, in the week ending January 27. The average weekly number of reported deaths from these causes in each month was as follows: —

January,	8	July,	192
February,	5	August,	154
March,	8	September,	88
April,	5	October,	57
May,	6	November,	13
June,	22	December,	8

The months having the greatest number of reported deaths from these causes in 1894 were July, August and September, and those having the least were February, April and May. The deaths from these causes in the third quarter of the year constituted 76 per cent. of the number of deaths from the same causes for the entire year. The ratio of reported deaths to the reported mortality from all causes was 84.21 per 1,000, and the death rate of the reporting population from these causes was 1.62, as compared with 1.71 in 1893.

Whooping-cough, Malarial Fever, Erysipelas, Puerperal Fever and Small-pox.

The essential statistics relating to these five diseases are embraced in the following table: —

	Total Deaths Reported.	Weekly Average.	Ratio per 1,000 of reported Deaths from All Causes.	Ratio per 1,000 of Estimated Population.
Whooping-cough,	282	5.0	9.92	.190
Erysipelas,	65	1.25	2.28	.044
Puerperal fever,	47	.9	1.65	.032
Small-pox,	28	.54	.98	.019
Malarial fever,	22	.4	.77	.015

II.

FATALITY (*RATIO OF DEATHS TO CASES*) FROM CERTAIN INFECTIOUS DISEASES IN 1894.

The figures in the following table are compiled from the published reports of local boards of health for 1894, which have been forwarded to the office of the State Board of Health. They relate chiefly to the four diseases which are usually reported by physicians to the local boards of health under the provisions of chapter 80, Public Statutes, section 79.

The number of deaths from each of the same diseases is also given. The chief value of this record consists in the ratio of fatality from each of these diseases, which is valuable in proportion to the number of cases and deaths thus accumulated. This will prove specially useful in the future, in furnishing data for the comparison of the fatality from diphtheria in the periods before and after the introduction of antitoxin as a life-saving agent.

The columns which contain the numbers of deaths may be considered as fairly accurate, while the figures representing the numbers of cases are probably a little less than the actual numbers, in consequence of the neglect or failure to report in a few instances.

The figures for 1894 are as follows: —

Reported cases of diphtheria and croup,	4,936
Registered deaths from diphtheria and croup in the same cities and towns,	1,376
Fatality (per cent),	27.88
Reported cases of scarlet fever,	7,416
Registered deaths from scarlet fever in the same cities and towns,	504
Fatality (per cent),	6.80
Reported cases of typhoid fever,	2,814
Registered deaths from typhoid fever in the same cities and towns,	488
Fatality (per cent.),	17.02
Reported cases of measles,	2,051
Registered deaths from measles in the same cities and towns,	37
Fatality (per cent.),	1.80

The cities and towns embraced in the foregoing list are 76 in number, being 6 more than those presented in the list of last year. They comprise about three-fourths of the total population of the State.

The number of reported cases of diphtheria and croup in this list was much greater than that of either of the three preceding years, while the percentage of fatality (27.9) was slightly less than that of 1892 and 1893.

The reported cases of scarlet fever were nearly the same in number as those of 1893, while the percentage of fatality (6.8) was less.

The reported cases of typhoid fever were greater by 357 than those of 1893, while the percentage of fatality (17.0) was considerably less.

The reported cases of measles were less than one-third as many as those of 1893, and the percentage of fatality (1.8) was slightly greater.

The following table presents a summary of these statistics for the four years 1891–94 : —

Reported Cases of Infectious Diseases in Massachusetts.

	Diphtheria and Croup.				Scarlet Fever.			
	1891.	1892.	1893.	1894.	1891.	1892.	1893.	1894.
Reported cases,	2,444	3,033	2,919	4,936	4,517	6,112	7,420	7,416
Deaths,	575	891	926	1,376	151	281	624	504
Fatality (per cent.),	23.5	29.2	31.7	27.9	3.3	4.6	8.8	6.8
Mean of four years,	28.3				6.1			

	Typhoid Fever.				Measles.			
	1891.	1892.	1893.	1894.	1891.	1892.	1893.	1894.
Reported cases,	2,414	1,892	2,457	2,814	5,861	783	6,290	2,051
Deaths,	460	435	492	488	84	31	98	37
Fatality (per cent.),	19.0	23.0	20.0	17.0	1.4	4.0	1.6	1.8
Mean of four years,	19.6				1.7			

The following figures present the fatality from diphtheria, scarlet fever and typhoid fever in England, as reported by the Local Government Board of England for the years 1890–93 : —

	1890.	1891.	1892.	1893.
Diphtheria,	25.5	23.7	23.6	24.5
Scarlet fever,	8.0	5.8	4.4	4.2
Typhoid fever,	19.9	20.8	17.8	17.0

Certain Diseases reported to Local Boards of Health in 1894.

Cities and Towns.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Adams,	3	8	58	5	12	3	1	-
Amesbury,	4	-	57	1	7	1	-	-
Attleborough,	16	6	10	2	19	3	2	-
Belmont,	1	-	10	-	-	-	-	-
Boston,	3,019	817	2,230	192	915	141	913	8
Bradford,	3	-	19	-	13	-	3	-
Bridgewater,	-	-	3	-	6	1	-	-
Brockton,	44	18	162	9	10	-	6	-
Brookline,	29	6	49	1	11	3	11	-
Cambridge,	176	61	901	101	120	23	-	-
Canton,	6	2	4	2	2	-	-	-
Concord,	27	4	46	-	9	1	-	-
Dedham,	1	-	5	-	11	2	3	-
East Bridgewater,	-	-	25	-	-	-	-	-
Easthampton,	-	-	30	-	-	-	-	-
Everett,	12	5	86	4	25	3	8	-
Fall River,	36	17	131	7	153	33	-	12
Fitchburg,	8	4	66	1	22	5	-	-
Framingham,	11	1	10	-	2	1	15	-
Franklin,	1	-	12	1	7	1	-	-
Gardner,	1	-	7	1	26	6	-	-
Gloucester,	50	15	58	-	23	3	-	-
Greenfield,	10	1	12	-	12	1	-	-
Haverhill,	15	4	98	2	84	7	5	-
Hopkinton,	3	1	-	-	-	-	-	-
Hudson,	19	6	6	1	7	1	13	-
Hull,	-	-	5	-	1	-	-	-
Hyde Park,	16	2	25	-	14	3	29	-
Ipswich,	22	7	18	-	9	3	8	-
Lawrence,	48	10	258	11	92	24	14	-
Leominster,	5	-	30	-	8	-	15	-
Lee,	2	-	19	-	-	-	-	-
Lowell,	47	37	304	16	282	50	27	-
Lynn,	101	20	250	8	54	12	-	-
Malden,	53	14	130	6	38	11	88	-
Marblehead,	24	4	89	1	14	2	-	-

Certain Diseases reported to Local Boards of Health in 1894 — Continued.

Cities and Towns.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Marlborough,	15	2	7	1	82	9	-	-
Medford,	19	3	78	10	19	2	5	-
Melrose,	31	10	32	1	23	5	33	-
Methuen,	7	-	44	-	-	-	-	-
Milford,	7	-	25	1	-	3	-	-
Millbury,	-	-	1	-	14	3	6	-
Nahant,	-	-	-	-	2	-	-	-
Nantucket,	3	2	-	-	-	-	-	-
Natick,	2	-	5	2	2	2	-	1
Needham,	1	-	3	-	-	-	-	-
New Bedford,	38	13	191	19	137	13	165	-
Newburyport,	20	4	10	1	12	4	-	-
Newton,	84	24	122	4	57	10	29	-
Northampton,	17	5	57	2	45	4	87	5
North Andover,	3	-	6	-	2	-	-	-
North Attleborough,	3	-	3	-	5	1	1	-
Orange,	1	1	1	-	13	3	1	-
Palmer,	-	-	13	-	6	-	6	-
Pittsfield,	15	6	90	4	16	4	16	-
Provincetown,	-	-	33	-	-	-	-	-
Quincy,	81	31	20	1	29	6	30	-
Reading,	4	-	4	-	4	-	1	-
Revere,	24	5	41	2	6	1	-	-
Salem,	29	6	248	9	70	9	-	-
Saugus,	4	1	4	-	4	-	-	-
Somerville,	110	28	452	51	58	13	-	-
Stoneham,	9	2	14	3	3	1	-	-
Swampscott,	2	-	4	-	-	-	-	-
Taunton,	174	50	67	2	3	5	-	-
Waltham,	175	23	99	1	13	2	-	-
Warren,	-	-	76	4	41	5	-	-
Wellesley,	10	4	12	-	-	-	1	-
Westfield,	3	1	14	-	-	-	-	-
Westford,	1	-	24	-	6	2	1	-
Weston,	5	1	5	-	3	1	-	-
Whitman,	11	5	150	-	2	2	1	-

Certain Diseases reported to Local Boards of Health in 1894 — Concluded.

Cities and Towns.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths
Winchendon,	3	1	17	4	3	-	-	-
Winchester,	7	2	55	3	10	2	22	-
Winthrop,	6	2	5	-	6	1	-	-
Worcester,	199	74	161	7	160	31	485	11
	4,936	1,376	7,416	504	2,814	488	2,051	37
	27.88		6.80		17.02		1.80	

Boston, . . . 77 cases of small-pox, 22 fatal.
Brookline, . . . 1 case of small-pox.
Cambridge, . . 4 cases of typhus fever; all immigrants taken ill within a few days after arrival; three were sisters who came in one steamer; all recovered.
Dedham, . . . 1 case of chicken-pox; also continued fever; 1 death.
Lowell, . . . 7 cases of small-pox, 3 fatal.
Lynn, ... 1 case of small-pox, fatal.
Marlborough, . . 1 case of small-pox.
Natick, . . . 1 case of small-pox.
New Bedford, . . 46 cases of whooping-cough.
Newburyport, . . 1 case of typhus fever.
Quincy, . . . 1 case of small-pox and 2 cases chicken-pox.
Randolph, . . . 1 case of small-pox.
Stoneham, . . . 1 case of small-pox.
Waltham, . . . 1 case of small-pox.
Wellesley, . . . 1 case of small-pox.
Worcester, . . . 16 cases of small-pox.

III.

REPORTS OF DISEASES DANGEROUS TO THE PUBLIC HEALTH FROM CITIES AND TOWNS UNDER THE PROVISIONS OF CHAPTER 302 OF THE ACTS OF 1893.

The first report under this act was that which was made for the fractional part of the year 1893 beginning with May, and may be found in the twenty-fifth annual report (pages 639–648). The present summary embraces the returns for the full year, 1894.

Previous to 1883 no law existed requiring reports of infectious diseases to be made by local boards of health to the State Board. In that year a statute was enacted requiring that all cases of small-pox should be notified to the State Board of Health immediately after such notice was received by the local board of health. Not until ten years later was this provision extended to other diseases dangerous to public health. By the terms of chapter 302 of the Acts of 1893 it is now required that notice of each such case shall be sent to the State Board of Health within twenty-four hours after its receipt by the local board.

A circular was issued by the State Board in September, 1893, giving public notice of this act, and at the same time expressing its opinion as to the diseases which should be regarded as coming within the provisions of the act; and in order to facilitate the operation of the law blank postal cards were printed, containing a form of notice, and these were issued to the local boards of health of cities and towns throughout the State.

The total number of cases of infectious disease reported during the year was 15,595. The number of reporting cities and towns was the same as that of the previous year, 175; but these cities were not identical with those which reported in 1893. Forty-two municipalities which reported in 1893 failed to report in 1894, and an equal number which had sent no returns in 1893 forwarded returns in 1894.

Eighteen of these towns in 1893 and 6 in 1894 were places from which only one case of infectious disease was reported during the year.

The diseases which were embraced in this summary, with the number of cases of each, are as follows: —

Diphtheria and croup,	4,178
Scarlet fever,	6,731
Typhoid fever,	2,372
Measles,	2,133
Small-pox,	181
Total,	15,595

The following table presents the names of the reporting cities and towns, with the number of cases of each disease reported by the local boards of health. The figures in this table differ from those in Section II. of this summary, being generally less. Those of Section II. may be taken as the complete returns in the cities and towns named in that table (page 790), while those in the following table represent the returns made by local boards to the State Board of Health. Where the name of a city or town occurs in each table the difference in the numbers given may be taken as the deficiency in returns made to the State Board from the local board of that place.

Cases of Infectious Diseases reported to the State Board of Health from One Hundred and Seventy-two Cities and Towns during 1894.

	Diphtheria.	Scarlet Fever.	Typhoid Fever.	Measles.	Small-pox.		Diphtheria.	Scarlet Fever.	Typhoid Fever.	Measles.	Small-pox.
Abington,	–	2	1	–	–	Auburn,	1	–	2	17	–
Acushnet,	–	9	–	–	–	Ayer,	2	24	2	1	–
Adams,	10	10	2	–	–	Barnstable,	1	2	–	–	–
Agawam,	–	–	–	–	–	Bedford,	5	2	1	–	–
Amesbury,	3	52	4	–	–	Belchertown,	–	1	7	–	–
Arlington,	7	24	6	–	–	Belmont,	–	2	–	–	–
Ashburnham,	1	–	–	–	–	Berlin,	–	2	4	3	–
Ashland,	1	–	–	1	–	BEVERLY,	7	32	19	24	–
Athol,	8	3	3	–	–	Billerica,	–	8	2	–	–
Attleborough,	14	19	12	3	–	Bolton,	–	3	–	–	–

Cases of Infectious Diseases, etc. — Continued.

	Diphtheria.	Scarlet Fever.	Typhoid Fever.	Measles.	Small-pox.
BOSTON,	2,265	1,587	550	699	73
Boxford,	–	2	–	–	–
Bradford,	1	6	8	–	–
Bridgewater,	–	3	7	2	–
Brimfield,	1	10	1	–	–
BROCKTON,	38	128	4	10	–
Brookfield,	1	11	–	9	–
Brookline,	12	26	2	6	2
CAMBRIDGE,	154	876	132	47	–
Canton,	2	6	–	–	–
Carlisle,	–	5	–	–	–
Clarksburg,	–	2	–	–	–
Chelmsford,	–	1	–	–	–
CHELSEA,	120	95	9	2	7
Cheshire,	–	1	–	–	–
CHICOPEE,	–	–	–	–	29
Clinton,	9	16	8	2	–
Concord,	24	29	10	–	–
Conway,	–	–	–	2	–
Cottage City,	–	–	2	–	–
Dalton,	–	–	–	–	1
Danvers,	–	57	7	–	–
Dedham,	1	8	5	3	–
Dighton,	10	7	–	–	–
Dover,	2	8	–	–	–
Dracut,	–	1	–	–	–
Dudley,	1	12	–	–	–
Duxbury,	1	9	–	1	–
East Bridgewater,	–	27	1	–	–
Easthampton,	–	5	–	–	–
Edgartown,	1	4	1	–	–
Erving,	–	–	1	–	–
EVERETT,	12	68	10	4	–
FALL RIVER,	25	109	110	2	–
FITCHBURG,	8	62	15	16	–
Foxborough,	8	12	1	1	–
Franklin,	–	–	4	–	–
Gardner,	–	1	–	–	–
Georgetown,	–	2	–	–	–
GLOUCESTER,	43	55	15	–	–
Grafton,	2	–	2	–	–
Granville,	–	2	3	2	–
Groton,	–	3	–	–	–
Groveland,	1	4	–	–	–
Hadley,	2	2	–	–	–
Hampden,	2	6	–	–	–
Hardwick,	12	5	–	–	–
Hayward,	–	8	–	–	–
Harwich,	–	1	–	–	–
HAVERHILL,	14	105	42	4	–
Hingham,	2	20	–	–	–
Hinsdale,	–	–	6	6	–
Holliston,	–	7	1	–	–
Hopkinton,	2	2	–	–	–
Hudson,	8	3	–	–	–
Hull,	2	6	1	2	–
Huntington,	–	6	3	–	–
Ipswich,	14	8	5	14	–
Kingston,	–	1	–	1	–
Lancaster,	–	–	1	–	–
LAWRENCE,	44	219	80	19	1
Leicester,	1	–	1	–	–
Leominster,	4	29	6	32	–
Leverett,	–	1	–	–	–
Lexington,	4	6	1	–	–
Lincoln,	2	6	–	1	–
Littleton,	–	9	–	3	–
LOWELL,	60	195	245	24	4
Ludlow,	1	3	–	–	–
Lunenburg,	2	4	–	–	–
LYNN,	88	176	48	2	1
MALDEN,	4	45	20	60	–

Cases of Infectious Diseases, etc. — Continued.

	Diphtheria.	Scarlet Fever.	Typhoid Fever.	Measles.	Small-pox.
Marblehead, .	1	85	6	–	–
MARLBOROUGH, .	4	3	45	–	1
Marshfield, . .	6	1	–	40	–
MEDFORD, . .	15	54	26	4	–
Methuen, . .	–	–	–	–	2
Milford, . .	4	15	6	–	–
Millbury, . .	1	4	11	8	–
Milton, . .	26	26	9	4	–
Montague, . .	1	14	–	–	–
Nantucket, . .	1	–	–	–	–
Natick, . .	1	2	–	151	1
NEW BEDFORD, .	38	133	123	158	–
NEWBURYPORT, .	11	5	8	–	–
NEWTON, . .	76	98	49	20	–
North Adams, .	21	58	76	48	–
NORTHAMPTON, .	15	55	48	77	–
North Andover, .	2	5	3	–	–
No. Attleboro', .	–	–	3	2	–
No. Brookfield, .	–	7	–	–	–
Norton, . .	1	–	–	–	–
Oakham, . .	–	–	–	2	–
Orange, . .	–	1	9	1	–
Oxford, . .	–	5	1	–	–
Palmer, . .	–	12	7	4	–
Peabody, . .	29	18	8	1	–
Pepperell, . .	4	16	–	–	–
PITTSFIELD, .	5	48	11	10	–
Plymouth, . .	14	8	7	1	–
Prescott, . .	–	–	–	4	–
Princeton, . .	–	–	–	1	–
QUINCY, . .	77	24	29	22	1
Randolph, . .	2	15	–	–	1
Raynham, . .	2	5	–	–	–
Reading, . .	4	2	–	–	–
Rockland, . .	7	28	3	3	–
Rockport, . .	9	11	1	2	–
Rowley, . .	1	2	5	–	–
SALEM, . .	23	232	67	–	–
Sandisfield, . .	11	–	3	–	–
Scituate, . .	1	2	1	17	–
Sharon, . .	2	1	1	–	–
Sherborn, . .	–	–	–	29	–
Shirley, . .	2	2	–	–	–
Shrewsbury, .	1	–	–	–	–
Somerset, . .	–	2	–	4	–
SOMERVILLE, .	96	388	56	–	–
Southborough, .	1	12	–	–	–
South Hadley, .	–	2	–	–	–
Southampton, .	–	5	–	–	–
SPRINGFIELD, .	18	123	68	27	1
Sterling, . .	–	4	–	–	–
Stoneham, . .	2	–	–	–	1
Sutton, . .	1	7	3	1	–
Swampscott, .	–	1	1	–	–
TAUNTON, . .	156	55	5	–	–
Upton, . . .	–	–	–	21	–
Wakefield, . .	4	4	1	–	–
Walpole, . .	–	2	–	1	–
WALTHAM, . .	104	89	12	–	1
Ware, . . .	1	3	–	–	–
Wareham, . .	11	15	–	–	–
Warren, . .	13	42	21	5	–
Watertown, .	14	28	6	12	–
Webster, . .	11	37	14	3	–
West Boylston, .	4	1	2	2	–
Westfield, . .	1	9	–	–	–
Westford, . .	1	22	5	1	–
Westhampton, .	–	–	–	21	–
Westminster, .	3	9	–	–	–
Weston, . .	3	8	2	–	–
Weymouth, .	13	42	13	–	–
Whitman, . .	13	111	3	–	–

Cases of Infectious Diseases, etc. — Concluded.

	Diphtheria.	Scarlet Fever.	Typhoid Fever.	Measles.	Small-pox.		Diphtheria.	Scarlet Fever.	Typhoid Fever.	Measles.	Small-pox.
Williamstown, .	26	26	18	-	-	WOBURN, . .	21	132	16	3	-
Winchendon, .	5	11	-	-	-	WORCESTER, .	170	127	115	388	17
Winchester, .	3	38	6	8	-	Yarmouth, . .	1	21	-	-	-
Windsor, . .	-	-	-	1	-	Other cases of small-pox,* .	-	-	-	-	35
Winthrop, . .	5	-	1	-	-	Totals, . .	4,178	6,731	2,372	2,133	181
Worthington, .	-	4	1	1	-						
Wrentham, . .	4	1	-	-	-						

Total, ... 15,595

Total number of reporting towns, ... 174

* These were cases of small-pox reported under the statute of 1883 by cities and towns which made no reports of other diseases under the law of 1893.

The following list comprises the cities and towns from which no returns were received. The probable cause of failure to report on the part of these municipalities is discussed in the last report, pages 647, 648. It is no more than just to repeat that in many of the towns of group IV., and in some of those in group III., it is quite probable that no cases of infectious disease occurred during the year.

List of Towns from which no Reports were received.

I. Cities.

HOLYOKE.

II. Towns having Populations of More than 5,000 in Each.

Amherst,
Andover,
Blackstone,
Braintree,
Framingham,
Greenfield,
Hyde Park,
Melrose,
Middleborough,
Northbridge,
Plymouth,
Revere,
Southbridge,
Spencer,
Stoughton,
Westborough,
West Springfield. — 17.

III. Towns having a Population of Over 1,000, but less than 5,000, in Each.

Acton,
Ashfield,
Barre,
Bellingham,
Bourne,
Brewster,
Buckland,
Carver,
Charlton,
Chatham,
Chester,
Cohasset,
Dartmouth,
Deerfield,
Dennis,
Douglas,
Enfield,
Essex,
Fairhaven,
Falmouth,
Freetown,
Gill,
Great Barrington,
Hamilton,
Hanover,
Hanson,
Hatfield,
Holbrook,
Holden,
Hubbardston,
Lanesborough,
Lee,
Lenox,
Longmeadow,
Manchester,
Mansfield,
Mattapoisett,
Maynard,
Medfield,
Medway,
Merrimac,
Middlefield,
Millis,
Monson,
Monterey,
Needham,
Newbury,
New Marlborough,
Northborough,
Northfield,
Norwood,
Orleans,
Pembroke,
Petersham,
Provincetown,
Rehoboth,
Rochester,
Royalston,
Salisbury,
Sandwich,
Saugus,
Seekonk,
Sheffield,
Shelburne,
South Abington,
South Scituate,
Stockbridge,
Sturbridge,
Sudbury,
Swansea,
Templeton,
Tewksbury,
Tisbury,
Townsend,
Uxbridge,
Wayland,
Wellesley,
Wellfleet,
West Bridgewater,
West Brookfield,
West Newbury,
Westport,
Wilbraham,
Williamsburg,
Wilmington. — 85.

IV. Towns having less than 1,000 Inhabitants in Each.

Alford,
Ashby,
Becket,
Berkley,
Bernardston,
Blandford,
Boxborough,
Boylston,
Burlington,
Carver,
Charlemont,
Chesterfield,
Chilmark,
Clarksburg,
Cummington,
Dana,
Dunstable,
Eastham,
Egremont,
Enfield,
Florida,
Gay Head,
Gill,
Granby,

IV. Towns having less than 1,000 Inhabitants — Concluded.

Greenwich,
Goshen,
Gosnold,
Halifax,
Hamilton,
Hancock,
Hawley,
Heath,
Holland,
Lakeville,
Leyden,
Lynnfield,
Marion,
Mashpee,
Mendon,
Middlefield,
Middleton,
Millis,
Monterey,
Montgomery,
Monroe,
Mount Washington,
Nahant,
New Ashford,
New Braintree,
New Salem,
Norfolk,
North Reading,
Otis,
Paxton,
Pelham,
Peru,
Phillipston,
Plainfield,
Plympton,
Richmond,
Rowe,
Russell,
Rutland,
Savoy,
Southwick,
Stow,
Sunderland,
Tolland,
Truro,
Tyngsborough,
Tyringham,
Wales,
Warwick,
Washington,
Wendell,
Whately. — 76.

IV.

The following summary comprises the returns from those cities and towns which are included in the provisions of chapter 218 of the Acts of 1894. This law required the local board of health of each city and town having a population of more than 5,000 inhabitants to "send an annual report of the deaths in such town to the State Board of Health. The form of such reports shall be prescribed by the State Board of Health."

In compliance with the provisions of this act the State Board of Health prepared a blank form and issued two copies to each of the boards of health in cities and towns having more than 5,000 inhabitants. The items provided for in this blank form were the following: —

Total number of deaths during the year, exclusive of still-births.
Total number of still-births.

Deaths of males.
Deaths of females.
Deaths in which the sex was unknown.

Deaths at each of fifteen age periods.
Deaths, ages unknown.

Deaths in each month of the year.
Deaths, date unknown.

Deaths from each of twenty-four specified causes.
Deaths from unknown causes.
Deaths from all other causes.

Table I. of this summary presents the names of the reporting cities and towns, with the number of the population in each.* The names of cities are printed in small capitals.

* The population here employed is an estimated population for the year 1894, based upon the increase from 1890 (the date of the United States census) to 1895 (the date of the State census). At the date of printing this report the first count of the State census only had been published. The second count or revision usually increases the first figures slightly, but not sufficiently to change any death rates which may be computed from the figures in this table.

Table II. presents the total number of deaths in each city and town, with the number of deaths of each sex and at each age period. The number of still-births is also presented in this table.

Table III. presents the mortality of each city and town by months.

Table IV. presents the mortality by causes of death under twenty-four titles, including the deaths from unknown or ill-defined causes and those from all other causes not specified under the other titles. The causes selected are chiefly those which are of sanitary significance.

TABLE I.

	Estimated Population, 1894.		Estimated Population, 1894.
Adams,	8,112	Middleborough,	6,567
Amesbury,	9,947	Milford,	8,923
Andover,	6,146	Montague,	6,102
Arlington,	4,864	Natick,	8,951
Athol,	7,152	NEW BEDFORD,	51,985
Attleborough,	8,145	NEWBURYPORT,	14,433
Blackstone,	6,063	NEWTON,	26,940
BOSTON,	484,701	North Adams,	18,516
BROCKTON,	31,891	NORTHAMPTON,	16,388
Brookline,	15,348	(Northampton Lunatic Hospital),	-
CAMBRIDGE,	79,079	North Attleborough,	6,606
CHELSEA,	30,586	Palmer,	6,779
CHICOPEE,	15,952	PITTSFIELD,	19,770
Clinton,	11,285	Plymouth,	7,829
Danvers,	8,036	QUINCY,	19,844
Dedham,	7,199	Revere,	7,083
EVERETT,	17,076	Rockland,	5,451
FALL RIVER,	85,109	SALEM,	33,676
FITCHBURG,	25,458	SOMERVILLE,	49,526
Framingham,	9,446	Southbridge,	8,126
Gardner,	9,031	SPRINGFIELD,	49,824
GLOUCESTER,	27,032	Stoneham,	6,253
Grafton,	5,082	TAUNTON,	26,756
Greenfield,	6,034	WAKEFIELD,	8,044
HAVERHILL,	29,609	WALTHAM,	20,423
HOLYOKE,	39,203	Ware,	6,268
Hyde Park,	11,501	Watertown,	7,645
LAWRENCE,	50,326	Webster,	7,637
Leominster,	8,825	Westborough,	5,224
LOWELL,	82,982	Westfield,	10,478
LYNN,	60,969	West Springfield,	5,913
MALDEN,	28,232	Weymouth,	11,201
Marblehead,	7,772	WOBURN,	14,041
MARLBOROUGH,	14,745	WORCESTER,	95,706
MEDFORD,	13,800	TOTAL,	1,876,941
Melrose,	11,277		

Beverly, no return; Peabody, no return.

Table II.

Total Deaths, Deaths by Sexes and Age Periods, and Still-births in Cities and Towns having over 5,000 Inhabitants in Each, by Census of 1890.

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths Under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.
Adams,	146	72	74	–	10	49	9	5	4	4	6	2	2	15	9	8	10	5	8	–	10
Amesbury,	162	69	93	–	8	28	8	3	5	–	4	1	6	7	12	13	20	16	15	24	–
Andover,	98	48	50	–	3	15	1	–	2	–	1	3	2	7	8	7	7	12	20	13	–
Arlington,	102	53	49	–	2	19	0	2	–	–	4	2	2	5	6	8	11	7	21	14	1
Athol,	122	60	62	–	3	19	7	2	–	–	–	2	4	14	11	12	7	13	18	11	2
Attleborough,	146	77	69	–	1	26	5	2	3	1	4	5	5	6	17	17	17	33	5	–	–
Blackstone,	125	72	53	–	13	27	8	4	1	–	1	3	6	16	13	8	8	7	14	9	–
Boston,	11,520	5,944	5,576	–	700	2,552	700	372	297	187	442	127	340	1,191	1,213	1,007	916	997	740	439	–
Brockton,	481	245	236	–	25	110	13	6	11	6	19	9	18	45	42	45	31	57	39	30	–
Brookline,	234	120	114	–	13	49	9	6	5	2	5	6	7	11	20	13	21	25	35	20	–
Cambridge,	1,559	740	819	–	89	381	106	55	38	42	70	27	53	133	106	110	116	109	130	83	–
Chelsea,	717	358	352	7	43	163	30	18	7	9	34	12	10	48	59	60	72	95	62	31	7
Chicopee,	326	178	148	–	10	120	35	10	5	7	8	2	10	25	14	9	23	25	22	10	1
Clinton,	203	101	102	–	15	48	9	6	5	1	8	5	5	13	17	11	32	22	12	8	1
Danvers,	186	112	74	–	4	10	4	–	–	1	–	2	4	6	23	29	24	29	27	21	6
Dedham,	133	63	70	–	3	19	4	1	1	–	–	4	7	11	11	8	11	15	26	15	–
Everett,	280	119	161	–	21	89	8	11	3	6	6	6	14	21	22	14	15	18	30	17	–

Fall River,	2,028	967	1,061	–	150	793	112	60	74	52	61	35	53	144	137	120	145	125	72	45	–
Fitchburg,	341	182	159	–	30	108	25	4	4	1	10	10	9	23	21	16	22	33	33	22	–
Framingham,	136	63	73	–	8	20	5	2	–	–	5	1	7	13	15	12	11	13	18	12	2
Gardner,	219	104	115	–	19	60	12	2	4	–	1	3	9	15	18	17	21	31	16	10	–
Gloucester,	406	218	188	–	29	131	*	*	*	*	12	†	†	29	21	26	34	44	34	26	–
Grafton,	74	39	35	–	8	15	3	–	3	2	–	3	2	5	4	1	7	13	7	9	–
Greenfield,	79	41	38	–	4	14	2	1	–	–	3	–	2	10	8	6	7	9	10	7	–
Haverhill,	505	276	229	–	34	113	26	8	6	3	13	13	14	40	57	40	50	45	51	26	–
Holyoke,	744	364	380	–	33	236	61	24	13	9	14	14	25	83	52	49	65	45	34	20	–
Hyde Park,	175	76	99	–	17	46	5	4	3	–	3	3	3	13	14	13	14	25	15	14	–
Lawrence,	925	415	510	–	74	253	56	16	13	10	22	20	37	90	96	75	69	83	55	26	4
Leominster,	135	62	73	–	13	28	3	1	–	–	5	2	3	12	9	11	8	17	23	13	–
Lowell,	1,775	898	877	–	142	541	111	52	23	24	43	49	49	185	156	124	130	122	115	51	–
Lynn,	896	425	471	–	80	208	35	12	8	5	28	12	30	101	75	45	93	84	87	70	3
Malden,	474	216	257	1	32	94	27	8	8	7	12	6	19	44	45	29	37	64	34	31	9
Marblehead,	143	71	72	–	10	25	4	4	5	–	6	3	4	11	8	11	17	13	20	12	–
Marlborough,	260	141	119	–	11	55	12	3	1	3	4	7	10	22	23	17	33	23	22	14	11
Medford,	205	97	108	–	8	40	9	6	2	2	18	2	6	15	14	19	16	22	19	14	1
Melrose,	177	87	90	–	13	82	‡		‡	‡	5	§	§	14	13	9	17	24	24	10	3
Middleborough,	107	60	46	1	3	10	1	1	1	–	8	1	2	6	10	4	9	18	24	17	–
Milford,	175	81	94	–	3	23	9	1	8	1	2	4	6	17	15	17	10	25	20	17	5
Montague,	114	69	45	–	7	42	6	–	1	2	4	2	3	6	8	8	5	7	12	8	–
Natick,	135	72	63	–	6	13	4	1	–	3	4	3	4	6	13	11	10	25	24	12	2
New Bedford,	1,037	525	512	–	91	346	64	26	15	13	25	12	26	74	60	77	74	94	78	53	–

* Forty-two between the ages of one and five years.
‡ Fifteen between the ages of one and five years.
† Seven between the ages of ten and twenty years.
§ Eleven between the ages of ten and twenty years.

TABLE II. — Concluded.

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths Under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.
Newburyport, ...	246	123	123	-	18	46	*	*	*	*	5	†	†	18	16	15	18	37	32	26	-
Newton, ...	417	189	228	-	20	95	27	7	8	5	11	9	10	39	25	28	28	52	42	29	2
North Adams, ...	301	134	167	-	18	73	14	8	8	4	11	8	13	31	21	34	14	27	23	10	2
Northampton, ...	226	109	117	-	6	43	15	5	6	-	5	1	3	19	13	15	26	20	37	16	2
(Northampton Lunatic Hospital).	38	28	10	-	-	-	-	-	-	-	-	-	-	1	4	5	11	9	6	2	-
North Attleborough, . .	102	51	51	-	3	16	1	1	1	1	-	1	2	6	9	15	14	13	11	11	-
Palmer, ...	127	69	58	-	11	40	14	1	1	-	1	3	6	10	8	3	7	10	15	8	-
Pittsfield, ...	304	136	166	2	24	74	15	11	9	1	10	3	7	32	31	20	24	23	24	18	2
Plymouth, ...	109	55	54	-	5	17	3	2	4	2	-	2	2	5	8	10	9	12	15	18	-
Quincy, ...	342	180	162	-	23	75	16	18	7	4	23	8	11	17	19	26	29	33	30	26	-
Revere, ...	111	60	51	-	6	31	3	2	4	1	5	1	4	8	14	7	12	6	11	2	-
Rockland, ...	86	43	43	-	-	13	1	2	-	-	2	1	1	7	15	6	9	14	8	7	-
Salem, ...	609	284	325	-	38	166	30	15	16	7	16	7	13	47	39	34	52	51	64	51	1
Somerville, ...	873	433	440	-	45	186	55	25	23	24	40	11	16	65	62	56	85	82	93	49	1
Southbridge, ...	171	94	77	-	3	46	22	7	6	7	8	3	10	8	8	4	6	14	16	6	-
Spencer, ...	124	59	65	-	5	31	4	2	2	2	1	4	6	13	9	8	6	13	9	9	5
Springfield, ...	800	395	405	-	40	191	39	7	11	7	17	7	30	71	61	63	71	87	89	47	2
Stoneham, ...	116	64	50	2	5	11	6	2	3	-	1	2	4	9	9	12	13	19	15	10	-
Taunton, ...	575	256	319	-	31	86	36	22	15	14	34	13	12	28	50	60	58	60	49	38	-
Wakefield, ...	123	72	51	-	2	33	6	1	1	1	1	1	3	13	9	13	6	9	16	10	-

Waltham,	272	146	126	-	26	52	12	8	3	4	14	5	7	23	24	23	16	27	30	24	-
Ware,	126	60	66	-	9	35	7	1	2	2	2	-	3	9	13	6	11	13	10	12	-
Watertown,	122	61	61	-	6	20	6	3	-	2	7	1	2	11	10	7	12	15	17	9	-
Webster,	175	92	82	1	4	61	18	3	2	-	5	5	5	11	12	12	6	7	15	12	1
Westborough,	140	89	51	-	1	8	3	-	-	-	1	3	2	9	13	19	16	28	18	20	-
Westfield,	166	85	81	-	4	33	9	4	-	1	5	2	5	15	12	8	16	22	19	14	1
West Springfield,	93	46	47	-	2	28	1	2	2	-	1	2	5	6	4	13	7	10	7	5	-
Weymouth,	187	93	94	-	8	33	6	-	3	1	5	1	8	14	16	14	14	26	28	17	1
Woburn,	286	151	135	-	12	77	13	10	4	5	8	-	6	24	22	25	23	31	25	13	-
Worcester,	1,728	862	866	-	109	345	‡	‡	‡	‡	60	§	§	157	162	157	194	183	140	77	-
	36,900	18,499	18,387	14	2,272	8,935	1,930	908	715	498	1,214	527	1,014	3,278	3,213	2,854	3,058	3,442	2,985	1,880	88

* Eighteen between the ages of one and five years.

‡ One hundred and seventy between the ages of one and five years.

† Fifteen between the ages of ten and twenty years.

§ Eighty-three between the ages of ten and twenty years.

TABLE III.

Deaths by Months in Each City and Town having a Population of More than 5,000 by Census of 1890.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Unknown.
Adams,	11	8	7	15	13	10	15	22	19	10	7	9	-
Amesbury,	16	12	13	15	24	7	13	14	14	7	15	12	-
Andover,	9	10	6	11	6	7	10	8	6	8	6	11	-
Arlington,	13	8	9	6	11	10	9	6	6	10	9	5	-
Athol,	12	7	9	7	8	10	12	12	9	12	12	12	-
Attleborough,	18	16	8	15	8	7	13	21	11	6	9	14	-
Blackstone,	19	20	11	9	7	4	16	9	7	6	9	8	-
Boston,	1,056	934	982	940	868	784	1,150	1,022	1,010	925	897	952	-
Brockton,	50	46	56	39	31	25	38	45	44	25	39	43	-
Brookline,	20	17	14	16	18	18	23	18	19	20	21	30	-
Cambridge,	148	135	116	98	120	131	174	155	135	152	94	101	-
Chelsea,	71	44	60	53	59	49	74	81	69	51	54	52	-
Chicopee,	28	33	28	29	31	23	40	25	23	27	11	28	-
Clinton,	19	14	19	18	21	17	18	19	17	14	11	16	-
Danvers,	22	22	16	17	12	16	12	19	16	16	8	10	-
Dedham,	10	11	11	9	11	10	18	13	15	8	11	6	-
Everett,	25	25	31	21	14	23	30	26	21	21	17	26	-
Fall River,	167	147	161	170	157	172	288	196	166	166	119	119	-
Fitchburg,	24	22	24	26	21	29	37	51	27	31	25	24	-

Framingham,	11	9	17	15	7	7	14	8	13	18	5	12	-
Gardner,	22	20	13	14	8	19	20	22	27	18	14	22	-
Gloucester,	33	20	47	23	32	28	39	49	39	31	33	32	-
Grafton,	7	7	2	7	10	7	6	6	9	1	7	4	1
Greenfield,	5	8	4	5	8	3	9	9	6	3	5	14	-
Haverhill,	47	37	45	61	41	38	41	37	53	36	34	35	-
Holyoke,	53	55	48	47	62	68	93	77	67	73	45	56	-
Hyde Park,	9	11	23	10	17	11	21	13	11	16	16	17	-
Lawrence,	77	66	75	66	59	67	139	104	68	62	63	79	-
Leominster,	17	8	14	14	4	6	7	11	16	15	10	13	-
Lowell,	178	160	150	130	117	116	203	155	153	147	126	140	-
Lynn,	63	70	80	66	71	60	73	99	89	60	82	83	-
Malden,	46	26	42	44	35	35	47	45	38	36	33	47	-
Marblehead,	9	15	14	12	10	8	15	15	14	7	10	14	-
Marlborough,	22	15	19	23	27	22	18	32	28	17	15	22	-
Medford,	17	15	13	19	9	14	33	20	14	10	19	22	-
Melrose,	16	13	12	27	13	16	14	12	13	9	14	18	-
Middleborough,	14	8	7	9	9	3	15	3	14	10	5	6	4
Milford,	25	15	10	9	16	8	19	31	13	12	10	7	-
Montague,	11	6	9	8	9	12	14	10	10	6	12	7	-
Natick,	17	14	13	7	12	8	7	13	17	8	7	12	-
New Bedford,	85	81	84	82	80	97	88	98	105	78	63	96	-
Newburyport,	18	21	19	21	24	18	25	22	25	15	15	23	-
Newton,	40	26	42	33	25	20	50	53	33	42	25	28	-
North Adams,	21	17	21	33	23	18	26	41	29	28	24	20	-

TABLE III. — Concluded.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Unknown.
Northampton,	22	15	10	12	23	15	31	25	25	18	12	18	-
(Northampton Lunatic Hospital),	5	3	2	4	3	2	1	6	4	3	1	4	-
North Attleborough,	8	9	11	7	6	9	5	9	12	7	10	9	-
Palmer,	9	10	16	6	6	8	19	16	13	8	6	10	-
Pittsfield,	24	15	15	27	22	23	35	33	29	39	23	19	-
Plymouth,	9	11	19	5	11	7	8	10	13	7	3	6	-
Quincy,	25	21	20	24	26	29	43	32	38	19	32	33	-
Revere,	8	2	6	8	3	9	18	19	15	8	8	7	-
Rockland,	11	4	8	6	8	12	3	11	2	10	7	4	-
Salem,	57	44	43	57	48	39	67	84	51	43	27	49	-
Somerville,	82	68	78	58	76	55	89	77	68	70	72	80	-
Southbridge,	18	27	18	10	13	12	7	18	13	15	11	9	-
Spencer,	26	9	14	8	5	8	10	10	14	8	6	6	-
Springfield,	60	46	63	82	51	79	95	81	54	55	68	65	1
Stoneham,	9	10	12	9	10	10	11	10	4	10	11	10	-
Taunton,	67	41	41	50	38	28	49	70	40	47	52	52	-
Wakefield,	12	6	11	12	11	12	10	13	12	13	4	7	-
Waltham,	31	16	25	21	19	20	20	20	28	27	18	27	-
Ware,	13	8	7	9	13	16	12	12	12	8	8	8	-
Watertown,	14	12	13	10	4	6	12	6	10	18	8	9	-
Webster,	13	12	11	11	11	13	27	19	21	12	13	12	-

Westborough,	15	8	5	12	15	10	15	13	12	14	12	9	-
Westfield,	10	12	13	14	13	13	27	20	21	11	5	7	-
West Springfield,	8	11	7	7	8	7	10	7	8	8	8	3	1
Weymouth,	22	11	12	18	19	13	8	14	18	18	19	15	-
Woburn,	27	22	18	17	20	15	34	17	18	23	37	36	2
Worcester,	187	146	121	127	144	120	191	152	140	134	132	134	-
By months,	3,393	2,873	3,023	2,930	2,794	2,651	3,883	3,551	3,233	2,926	2,679	2,955	9
	*108.3	*101.5	*96.5	*96.7	*89.1	*87.5	*124.0	*113.3	*106.2	*93.4	*88.3	*94.3	-
By quarters,	-	9,289	-	-	8,375	-	-	10,667	-	-	8,560	-	-
	-	*102.1	-	-	*91.04	-	-	*114.7	-	-	*92.04	-	-

* These figures show the monthly and quarterly mortality reduced to a standard of 100, for the purpose of convenient comparison; by this method the inequality in length of the months and quarters is eliminated.

TABLE IV.

Deaths from Specified Causes in Cities and Towns having More than 5,000 Inhabitants in Each, by Census of 1890.

	Consumption.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
Adams,	16	-	5	8	3	3	8	-	1	-	1	21	3	1	8	3	5	16	2	4	1	3	-	34
Amesbury,	22	-	5	1	-	3	2	-	2	2	-	4	-	-	24	6	13	3	6	13	-	2	9	44
Andover,	15	-	-	4	-	4	-	-	-	1	-	-	-	-	8	4	8	6	1	7	2	1	-	37
Arlington,	12	-	2	-	-	-	-	1	-	-	-	2	-	1	10	2	15	11	12	7	1	2	2	22
Athol,	14	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	10	4	4	4	-	4	-	74
Attleborough,	14	-	2	6	-	3	-	-	-	1	-	10	2	1	14	3	11	7	6	-	1	5	-	60
Blackstone,	16	-	-	2	-	8	4	-	-	-	-	2	-	2	8	4	2	5	6	3	2	7	-	54
Boston,	1,425	8	192	878	111	141	18	32	16	56	5	569	38	93	1,119	460	839	679	373	354	59	415	23	3,574
Brockton,	78	-	9	18	10	5	2	-	2	13	-	16	1	4	54	2	39	20	15	9	5	7	2	170
Brookline,	34	-	1	6	3	3	-	-	-	2	-	15	-	1	14	8	19	-	8	13	2	2	-	103
Cambridge,	180	-	103	63	35	27	1	2	5	11	1	99	3	72	110	57	108	175	47	51	4	38	144	221
Chelsea,	76	-	8	38	2	5	21	1	-	-	-	28	2	18	42	28	40	6	11	15	2	9	1	364
Chicopee,	30	4	-	13	5	2	1	-	-	4	3	28	3	4	15	12	16	43	4	9	1	8	4	115
Clinton,	17	-	-	10	2	4	9	-	1	-	-	8	2	5	8	3	14	4	4	2	1	4	-	105
Danvers,	18	-	-	-	-	1	-	2	-	7	-	2	-	7	16	3	24	58	14	8	-	3	-	23
Dedham,	17	-	-	-	-	2	3	1	-	-	-	3	4	3	14	3	13	5	6	3	-	9	1	46
Everett,	44	-	4	6	1	3	-	2	1	2	1	11	-	10	22	8	27	57	9	7	-	6	-	59
Fall River,	139	12	7	39	27	33	3	5	2	11	1	193	3	33	139	125	80	292	67	37	2	59	15	704

Fitchburg,	25	-	1	4	8	5	1	1	1	2	-	29	1	4	17	10	35	17	6	10	-	4	-	160
Framingham,	30	-	-	1	-	2	1	1	-	3	-	3	-	-	10	2	6	1	12	5	1	5	1	52
Gardner,	25	-	1	2	-	6	20	-	1	-	-	13	5	2	26	6	11	11	8	5	1	4	23	49
Gloucester,	34	-	-	15	9	3	1	1	1	3	-	29	1	6	24	6	20	51	11	23	3	8	-	157
Grafton,	11	-	-	1	-	2	1	-	-	1	-	8	-	-	7	-	6	-	-	1	-	2	-	34
Greenfield,	10	-	-	1	-	1	1	-	-	1	-	4	-	4	8	2	8	9	3	3	1	5	-	18
Haverhill,	72	-	2	5	-	7	-	4	4	5	-	14	1	10	66	25	42	7	9	11	3	15	8	195
Holyoke,	132	17	2	14	-	8	2	3	10	12	4	144	17	8	40	37	38	72	40	20	1	7	33	80
Hyde Park,	19	-	-	2	1	3	9	-	1	-	3	7	-	3	15	3	12	-	6	8	1	3	-	79
Lawrence,	72	-	10	10	8	24	6	2	3	4	1	99	4	9	75	16	44	2	20	20	4	14	12	466
Leominster,	13	1	-	-	2	2	5	-	-	-	-	7	-	1	15	2	19	-	5	3	-	2	-	58
Lowell,	209	-	16	37	7	50	3	8	4	28	1	223	5	9	139	92	123	205	47	48	5	57	2	454
Lynn,	104	-	8	22	5	12	37	2	1	3	1	42	7	13	59	11	64	10	17	28	3	7	5	434
Malden,	55	-	7	20	3	12	24	2	-	4	-	23	2	21	42	13	53	53	27	12	1	13	3	84
Marblehead,	15	-	4	7	-	4	2	-	1	-	-	3	3	2	6	5	18	4	3	10	-	2	-	54
Marlborough,	38	-	1	4	3	9	-	1	-	-	-	23	2	5	28	1	19	1	16	7	2	2	-	98
Medford,	26	-	10	4	2	2	-	-	-	-	1	10	-	14	17	2	27	1	3	8	1	6	-	71
Melrose,	20	-	1	11	2	5	-	-	-	-	-	6	1	1	10	6	26	-	1	9	-	2	2	74
Middleborough,	19	-	2	-	-	-	-	2	2	-	-	4	-	-	6	-	18	5	5	4	-	5	10	25
Milford,	35	-	1	-	3	3	5	1	11	-	1	11	1	1	15	-	21	14	11	1	-	5	1	34
Montague,	13	-	2	2	-	-	4	-	1	1	13	14	-	2	2	3	8	10	7	1	-	3	9	19
Natick,	15	1	2	-	1	2	1	-	-	-	1	1	-	2	12	3	11	-	9	6	1	7	3	57
New Bedford,	105	-	19	14	2	13	4	-	1	6	-	71	3	10	85	37	92	6	43	34	2	-	14	476
Newburyport,	26	-	1	4	2	4	4	-	-	2	1	12	-	2	17	6	19	4	8	11	1	5	1	116
Newton,	31	-	4	24	10	10	-	-	1	-	-	22	3	6	24	6	44	8	15	19	1	6	6	177

TABLE IV. — Concluded.

	Consumption.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
North Adams, . . .	21	-	11	4	3	21	-	1	-	5	2	26	3	4	34	5	22	29	9	12	1	11	2	75
Northampton, . . .	22	4	2	5	-	4	2	1	1	3	1	20	3	3	14	10	23	24	9	12	3	9	-	51
(Northampton Lunatic Hospital.)	5	-	-	-	-	-	-	1	-	-	-	-	1	-	-	2	6	18	1	1	-	-	-	3
North Attleborough, .	20	-	-	-	-	1	-	-	-	1	-	9	1	2	4	4	10	13	5	4	1	1	-	26
Palmer, ...	9	-	-	-	2	3	7	-	1	6	-	18	-	1	12	7	8	8	3	4	-	5	-	33
Pittsfield, ...	32	-	4	6	5	4	-	1	3	1	-	19	2	4	16	3	9	22	6	12	5	7	2	141
Plymouth, . . .	8	-	-	4	-	1	-	-	-	-	-	3	-	-	3	3	21	12	3	3	-	5	-	43
Quincy, ...	42	-	1	30	6	7	4	-	-	-	-	21	1	5	21	1	37	18	8	9	3	11	2	116
Revere, ...	3	-	2	5	1	1	2	-	-	-	-	12	2	2	7	1	10	2	11	2	3	11	-	34
Rockland, . . .	17	-	2	2	-	-	1	-	1	-	-	5	-	1	4	3	11	8	5	3	1	3	-	19
Salem, ...	35	-	7	20	8	10	3	-	2	7	-	42	9	9	23	20	48	11	1	19	4	4	-	327
Somerville, . . .	89	-	51	35	13	13	-	5	-	3	-	34	4	18	79	24	56	18	24	22	5	21	-	359
Southbridge, . . .	23	-	7	3	3	1	-	1	-	1	-	23	-	2	15	10	8	21	4	3	-	5	-	41
Spencer, ...	15	-	-	2	-	2	3	-	-	-	-	8	2	1	9	-	10	4	3	4	3	3	-	65
Springfield, . . .	97	6	3	12	10	16	4	-	3	11	4	94	-	7	56	25	69	23	42	27	9	35	32	215
Stoneham, . . .	13	-	3	2	1	4	4	1	2	-	-	4	3	1	12	-	11	13	5	5	1	2	-	28
Taunton, ...	65	-	2	174	6	5	10	1	-	-	1	21	2	3	36	10	-	5	-	9	-	5	-	220
Wakefield, . . .	13	-	3	2	-	2	11	-	-	-	-	6	-	1	7	5	9	5	7	4	-	7	-	41
Waltham, . . .	38	-	1	23	-	2	1	2	-	1	2	11	-	1	28	5	21	3	-	8	-	9	-	116

Ware,	11	-	-	-	3	1	-	-	-	5	-	16	2	-	6	5	9	12	6	7	-	3	-	40
Watertown,	20	-	2	7	1	3	11	-	1	-	-	1	-	-	13	2	11	9	3	3	-	2	-	33
Webster,	5	1	-	6	1	8	2	1	2	-	1	28	2	3	8	2	9	24	5	2	-	4	5	56
Westborough,	12	-	-	-	-	3	1	5	-	-	-	3	2	1	7	3	13	69	4	4	-	2	-	11
Westfield,	11	-	-	1	2	1	3	-	-	2	1	21	-	3	16	1	40	18	6	8	2	9	-	21
West Springfield,	4	-	-	1	-	-	1	-	-	1	-	9	-	-	6	3	8	8	6	3	1	10	-	32
Weymouth,	28	-	1	7	1	2	6	-	-	3	-	2	-	-	15	4	13	15	9	4	2	5	2	68
Woburn,	20	-	13	5	1	19	-	-	2	1	2	12	3	-	17	6	37	10	12	6	1	2	-	117
Worcester,	194	12	7	76	18	31	-	2	9	5	-	125	4	12	177	52	149	349	93	58	7	50	-	297
	4,193	66	554	1,728	352	601	279	96	100	241	53	2,426	163	474	3,043	1,241	2,745	2,653	1,217	1,111	167	1,014	379	11,948

	Homicide.
Amesbury,	1
Boston,	21
Cambridge,	2
Quincy,	1
Stoneham,	1
Worcester,	1
Total,	27

	Small-pox.
Boston,	22
Chicopee,	2
Holyoke,	3
Lowell,	3
Lynn,	1
Total,	31

The estimated total population of these cities and towns in 1894 was 1,876,941, or a little more than three-fourths of the estimated total population of the State for the same year. The number of deaths in the same places was 36,900 and the death rate per 1,000 was 19.66.

HEALTH OF TOWNS.

HEALTH OF TOWNS.

The following digest comprises such abstracts as have been made from reports of local boards of health which have been forwarded to the office of the State Board for the year 1894.

The table of reported infectious diseases, which it has been customary, during the past three years, to print in connection with these abstracts, has been transferred to a previous page, where it is presented as Section II. of the statistical summaries.

The principal topics which appear to be prominent in the following abstracts are the need of hospitals for contagious diseases in cities and populous towns, the introduction of registration of plumbers and the regulation of plumbing by local boards of health, and the need of public systems of sewerage and sewage disposal in places already provided with public water supplies.

Health of Towns.

Adams.

Number of nuisances inspected,	24
Number of nuisances abated,	22

Amesbury.

There were 56 complaints of nuisances filed during the year, as against 81 the previous year. Most of these were caused by want of a proper system of sewerage for the town. The property owners have shown in most cases a prompt and cheerful willingness to comply with all the requirements of the board, to have all nuisances promptly abated.

We would recommend that the provisions of the statutes relating to vaccination should be regularly enforced. They are now almost wholly neglected, which may result in future disaster.

Scarlet fever has again prevailed in various sections of the town, furnishing 57 cases, as against 89 in 1893. The type of the disease has been unusually mild, causing but 1 death, or less than 2 per cent., while last year it was 16 per cent. Every effort has been made by this board to prevent the spread of this disease. Each house has been immediately posted

where a case was reported to exist, and great care taken to have the apartments thoroughly disinfected.

We would again (for the eighth year) urge upon the voters that the town should build and equip a complete system of sewerage the present year. It must be done sooner or later.

Arlington.

The regulations adopted by the town, in consequence of the statute relating to the business of plumbing throughout the State, have been impartially enforced in the interests of the citizens of our town who employ plumbers, as well as for the protection of those in the town who are engaged in the plumbing business. The importance and value of the inspections will become more apparent each year. A complete record is kept by the inspector of each building examined, and the information contained in those records will prove of much value to those who may wish to purchase buildings in the town, as they can ascertain just what quality of work has been put into them.

Attleborough.

There have been 107 fewer cases of infectious diseases during the year than in 1893. This, no doubt, has been owing to a more rigid quarantine of persons suffering from such, and the exclusion from school, for a longer period than has heretofore been required, of children living in houses where such diseases have existed. In view of the prevalence of diphtheria in many towns of the Commonwealth, and of the fact that it is very difficult to detect the disease in its mild form, the board desires to emphasize the importance of absenting all children from school who are suffering with sore throats, however mild, and of notifying the family physician at once. Teachers of our schools will do well, and do much to lessen the spread of this most fatal disease, if they will prohibit from attending school any child suffering from sore throat. Any child having a rash upon its body should be sent home at once, and not allowed to attend school again without a certificate from a physician stating that it is not of a contagious nature.

The great difference in the number of infectious diseases between this and last year is due to the prevalence of measles during the year of 1893. Since the exclusion from school, for a period of two weeks dating from the extermination of the last case in such houses, of children living in houses where this disease has been, it has gradually died out, only 2 cases having been reported during the past year.

There have been but 10 cases of scarlet fever during the year, 3 of them occurring in a family where the parties were visiting, who had left their homes to escape the disease, it being very prevalent in their town. Last year 30 cases were reported.

There have been 14 deaths from tuberculosis during the year, the number of cases not being reported.

Nineteen cases of typhoid fever have been reported, being 7 more than in 1893.

Belmont.

Three houses have been fumigated by the board, the remainder by the occupants themselves, in a manner satisfactory to us.

In midsummer the board inspected the majority of the places in which swine are kept, and found them in good condition. Four complaints have been received in writing, and the nuisances were inspected and abated.

Boston.

The total number of deaths for the year was 11,520, a decrease from the previous year of 190 deaths. The population, as estimated in the middle of the year, is 501,107, which is based on the geometrical rate of increase between the last two census years, 1885–90. The death rate for the year, as calculated on this population, is 22.98 per 1,000 inhabitants. This rate is less by 1.04 than that of the previous year, and the lowest since 1890.

The excessive prevalence of pneumonia, which caused the largest number of deaths in 1893, has subsided, and consumption resumes its former place as the principal factor in the city's mortality. The deaths from this latter cause numbered 1,425, which is 12.36 per cent. of the total mortality. The deaths from pneumonia numbered 1,119, or 9.71 per cent. of the total.

Diphtheria became epidemic during the year, causing 817 deaths, and its increase was noticeable in every month of the year over those of 1893. It assumed an epidemic form in the last week of September, reached its climax about the first week in December and gradually fell off at the end of the year. It is noteworthy that during the past four years in this city this disease has shown an increasing tendency, the rate per 1,000 inhabitants being .505 in 1891, .881 in 1892, .976 in 1893 and 1.630 in 1894.

Of the other contagious diseases reported during the year, the deaths from scarlet fever, typhoid fever and measles were respectively less than the year previous.

The increase in diphtheria and cholera infantum raised the number of deaths due to zymotic causes to 2,357, an increase of 315 deaths of this class over the previous year, or a percentage of 20.46 to the total mortality.

The deaths of children under five years of age were also increased to 4,108, or 35.66 per cent. of the whole number of deaths. This is the highest per cent. since 1887, and the highest number of deaths for any one year on record. The increase of deaths of children was due to diphtheria, cholera infantum and an unusually large number of enteric diseases, the result of malnutrition.

There were 77 cases of small-pox, with 22 deaths, all of which occurred in the first five months of 1895.

Many very full tables, illustrated with diagrams, accompany the report, presenting the mortality of the city by ages, causes of deaths, sexes and seasons for a series of years. Comparative tables are also given, presenting the same statistics for several large American and foreign cities.

The prevalence of the disease in epidemic form made it possible for the board of health to introduce three new forces for the suppression of the disease. One is the new remedy, "antitoxine," which has been used to a limited extent, with excellent results in reducing the percentage of deaths to the number of cases. It is also claimed for antitoxine that it possesses the power of preventing an attack of diphtheria for a brief length of time, when used during or immediately after exposure to the disease. To what extent this probable quality of the agent may in the future be made available remains to be seen, but thus far it cannot be said to have been an active agent in diminishing the number of cases. Another agent has been found in the use of the bacteriological laboratory, by which a large number of mild cases of this disease are found to exist. This has given rise to early treatment and isolation, where the ordinary means of diagnosis have heretofore left such cases to go as ordinary sore throat. The laboratory test is proving of great service also in determining the time when it is safe to discharge the diphtheritic patient from isolation. The third and probably most potent agency in controlling the spread of this disease and that of scarlet fever is the new force of fifty physicians for the daily inspection of the schools, in which there are more than seventy thousand of the most susceptible subjects to these two diseases. This has set in practice the most active, constant and skilful watchfulness for the earliest symptoms of these and other diseases among school children. The same agency has been used in watching and securing such isolation as might be possible of all cases of diphtheria and scarlet fever within the city, and certifying the time of their full recovery. By the latter means the earliest appearances of the disease, its development, isolation and disappearance are brought directly under the agency of the board of health.

On the advent of the recent epidemic of diphtheria, the board of health, finding itself in possession of sufficient funds to carry on the work, made an arrangement with Professor Ernst for this work to be done at the Harvard medical laboratory. Dr. McCollom, the physician to the board, having qualified himself in bacteriological work, was relieved from other duties and assigned to this. His work in the laboratory has been of great value in connection with the other new means now in use for the suppression of diphtheria.

All physicians were invited to take cultures from throats where diphtheria was suspected, and for their convenience culture tubes in cases were provided and stations were established at drug stores, where physicians could obtain tubes for cultures.

Dr. Ernst contributes a report of the work which the board had entrusted to him, of preparing a supply of antitoxine, to be distributed under the direction of the board. This work is conducted at Gallop's Island in Boston Harbor, and was entered upon in January, 1895.

Registration of Plumbers.

For the year ending Jan. 31, 1895, the examining board held 21 meetings and examined 213 candidates for plumbers' licenses; 72 were examined for master plumbers' licenses, and 36, or 50 per cent., passed the examination and were licensed; 141 were examined for journeymen plumbers' licenses, and 129, or 91 per cent., passed and were given licenses.

Medical Inspection of Schools.

The need of medical inspection of schools, for the purpose of detecting contagious and other diseases among the school children, was brought to the attention of the mayor and city council in 1892; and for this purpose an appropriation was then secured. A delay of several months was occasioned in securing the approval of the school committee, so that the plan did not finally go into operation till November, 1894, when the board of health selected fifty physicians for this purpose, divided the city into fifty school districts, and began school inspection. These physicians are appointed medical inspectors of schools and agents of the board of health, and are authorized to visit each school daily, during the early part of the morning session, and to examine all pupils who complain, or appear to the teachers to be ill. If an inspector finds a pupil showing symptoms of any contagious disease, or is otherwise too ill to remain in school, he will advise the teacher to send the pupil home for the temporary observation of its parents or family physician. He will also give such professional advice as may be required by the teachers to aid them in carrying out all laws and regulations pertaining to contagious diseases, vaccination and general school hygiene, whose enforcement belongs to the school committee or board of health. In the examination of throats, the medical inspectors will use only the wooden tongue depressors which are furnished by the board of health, each of which is to be burned after a single use.

The medical inspectors of schools are also authorized agents of the board of health; and will, on notification from said board, visit all cases of scarlet fever and diphtheria at the homes of the patients, for the sole purpose of examining the places and plans of their isolation; and, as such agents, they will report to the board of health their approval or disapproval of such places and plans of isolation. Such medical agent will not prescribe advice or criticise anything beyond that which pertains strictly to the isolation of the patient, and will carefully avoid any word or act which may be construed as an infringement upon the rights of the family or at-

tending physician. He will visit the patient as often as may be necessary to inform himself as to the continued isolation of the case. No case of scarlet fever or diphtheria will be discharged from isolation until its complete recovery is certified to the board of health by one of its medical agents; and such certificates of recovery will be based on the complete disappearance of desquamation in cases of scarlet fever, and on the absence of the Klebs-Lœffler bacillus in cases of diphtheria, — the latter to be shown by bacteriological examination made satisfactory to the board of health.

The reports of the medical inspectors of schools, for the months of November and December, show that 4,962 pupils were presented to them for examination; 564 were found to be too ill to remain in school for the time being, 212 were suffering from contagious diseases, 43 were suffering from diphtheria and 131 were too ill from troubles in the eyes and ears to be in school. Diseases in the throat were most prevalent, and were found in 1,749 pupils. Diseases of the eye, ear, and spine are found sufficiently often among the school children to warrant a more careful examination to find those who may be suffering from mild forms or early stages of these diseases. It often happens that school children suffer serious and unrecognized disadvantages by reason of defective eyesight, deficient hearing or a commencing deformity of the spine. The mild forms and early stages of these ills would not generally be seen and appreciated by the teachers, and it would be unreasonable to expect them to detect illnesses which require special skill on the part of the physician to recognize.

Tenement-Houses.

Every tenement-house in the city has been inspected at least twice during the year, and many of the poorer class have been examined every month or oftener; and, as is usual with the poorer class of buildings, a large number of notices have been issued from the department, ordering the abatement of nuisances existing therein, necessitating frequent subsequent visits to ensure a compliance with the notices.

Overcrowding in tenement-houses is not so prevalent as it has been in former years. Although still prevailing in some sections of the city, this state of things can only be determined for a certainty by visits after midnight, which are required by inspectors in the tenement-house districts during the winter months.

Wet Lands.

Under the operation of chapter 342 of the Acts of 1893 it has been found possible to compel the filling of wet lands, where heretofore it has been difficult because of a lack of sufficient authority to deal with the owners of such lands. By authority of this act upwards of fifty different

individuals and corporations have been served with legal notices by different sheriffs and constables throughout the Commonwealth. These notices set forth that the board of health had adjudged that the public health required that certain lands owned by the parties so notified be filled to the grade of eleven feet above mean low water, in such a manner as not to create a nuisance, and with good clean gravel or other suitable material.

Paving Private Passageways.

The Legislature of 1894 enacted a law to the effect that when the board of health shall adjudge that the public health requires and shall order that any private passageway shall be paved or provided with a suitable road-bed, the owners shall forthwith lay such road-bed in a manner satisfactory to said board. By authority of the said law fourteen private passageways were during the year provided with a stone or macadam pavement, by direction of the department.

Vaults, Nuisances, etc.

The number of vaults discontinued in 1894 was 171, making 7,665 in all since the enactment of the law authorizing such action.

The number of nuisances abated during the year was 6,840, and 793 complaints were investigated which did not require action.

Disinfection.

The total number of rooms disinfected by the disinfecting corps was 9,813, nearly all of which (97 per cent.) were in cases of diphtheria and scarlet fever. There were also 70,057 disinfections conducted in yards, cellars, vaults, cesspools, water-closets, gutters, etc., the materials used being 1,625 pounds of bichloride of mercury, 38,920 pounds of chloride of lime, 48,978 pounds of sulphur and other substances.

Garbage Disposal.

The board furnished a dumping boat or scow in 1884, which was turned over to the street cleaning department in 1886. In 1894 a small experimental plant was constructed in Dorchester for the reduction of garbage, a place having been assigned for the work by the board of health. The contract provided for the treatment of not more than twenty tons of garbage daily.

Public Baths.

The total number of bathers of both sexes at the public bath houses during the season of 1894 was 1,082,675.

Report of Physicians to the Board of Health.

There were 2,371 persons vaccinated, and certificates of vaccination were given to 1,524 school children.

The deaths of 381 persons dying without the attendance of a physician were investigated. These cases comprise principally those who die from chronic disease, where there has been no medical care for months previous to death, and those who die suddenly from natural causes. In these cases a careful external examination is made, the symptoms learned and a diagnosis sufficiently accurate for all practical purposes reached. The law requires a medical certificate of death before a permit for burial is granted, and these examinations are made to conform to the law, as well as to collect statistics for bills of mortality.

Infectious Diseases. — One hundred and twenty cases reported as small-pox have been examined; of these 77 proved to be small-pox. Sixty-nine of these patients were sent to the small-pox hospital on Canterbury Street, where 18 of them died. Eight patients were sent to the hospital on Gallop's Island, and of these 2 died. The statement of the remaining 43 reported cases is as follows: eczema, 5; measles, 7; postular dermatitis, 4; syphilis, 6; urticaria, 3; varicella, 18.

Three hundred and fifty-two cases of varicella were investigated during the year for the purpose of verifying the diagnosis.

On the first of November an arrangement was made with Prof. Harold C. Ernst, by which physicians could send cultures for examination to the bacteriological laboratory of the Harvard Medical School. In November and December 1,002 cultures were examined. The bacillus of diphtheria was found in 246 instances; in 699 cases the bacillus of diphtheria was absent, and in 57 instances there were no growths. During the month of January, 1895, there were 842 cultures examined. Of this number 216 showed the presence of the bacillus of diphtheria; in 593 instances the bacillus of diphtheria was not found, and in 33 instances there were no growths. It is evident, from the marked increase in the number of cultures sent to the laboratory during the month of January, as compared with that of the two previous months, that the importance of this work is becoming more generally appreciated by physicians.

Report of Inspector of Animals at Abattoir.

Animals killed at Abattoir.

Cattle,	26,025
Calves,	11,076
Sheep,	62,108

Animals condemned.

	Number.	Weight.
		Pounds.
Cows,	41	18,211
Steers,	5	4,485
Bulls,	5	4,000
Calves,	4	185
Parts of animals,	–	4,250
Total,	55	31,131

Diseases found among Animals after having been killed and dressed at the Abattoir.

Diseases.	Cattle.	Calves.	Sheep.
Tuberculosis,	58	–	–
Septicæmia,	8	–	–
Puerperal fever,	1	–	–
Actinomycosis,	·17	–	–
Enteritis,	–	1	–
Bruised,	1	–	–
Immatured,	–	3	–
Total,	85	4	–

Tuberculosis.

The following table shows the percentage of cattle killed with the intention of being used for food : —

Class of Animals.	Number Received.	Tuberculosis.	Percentage.
Whole number of all kinds,	26,025	58	0.24
Cows from eastern States,	1,886	56	2.97
Bulls from eastern States,	–	2	–
Steers from eastern States,	–	–	–
Cows from western States,	–	–	–
Steers from western States,	–	–	–

Under the head of cows from eastern States is understood those animals from all of the New England States, including Massachusetts.

Previous to June, 1894, the carcasses of animals slaughtered at the abattoir, showing the presence of very slight lesions of tuberculosis (as a small nodule in a lymphatic gland and the animal otherwise in good condition), had not been condemned.

Inspection of Cattle.

The work of inspection of cows, as provided for by the Board of Health, and subsequently made compulsory upon cattle in general by an act of the Legislature, has been continued during the past year.

All cattle which upon inspection have shown any symptom of tuberculosis have been tested with tuberculin, which has been supplied by the United States Government Bureau of Animal Industry, and all animals which have shown characteristic reaction to such test have been quarantined, and the State Board of Cattle Commissioners notified. Twenty-six animals have been quarantined under these conditions and reported to the State Board of Cattle Commissioners.

Bradford.

Sixty-five buildings have been inspected by the agent. Sixteen notices have been served by the board, in addition to many personal instructions given by all the members of the board.

Bridgewater.

The health of our people has been remarkably good; no contagious or infectious disease or epidemic of any kind has prevailed among us; and we have reason to believe that the careful and constant supervision of the sanitary condition of the town, continued from year to year, has, by the blessing of God, secured to our citizens immunity from "many ills that flesh is heir to."

For clearing of cesspools the excavator has become a prime necessity, and the wonder now is how we could have dispensed with it so long. There is an increasing demand for its use and an increased satisfaction with the results. Two hundred loads have been removed, against 150 last year.

Brockton.

The total number of deaths in the city during the past year was 481, exclusive of still-births, an increase of 22 over the year 1893. Estimating the population of the city at 33,939 (which is the State Board of Health estimate), the death rate would be 14.17 for each 1,000 of the population, which must place our death rate among the very lowest of any of the cities and large towns in the State.

A large number of the blocks and business places on the line of the sewer have connected with the sewer, which has largely reduced the

amount of work formerly done by the excavator wagons. Some manner of disposing of the large amount of waste paper that accumulates in the city must be provided for in the near future, and we would recommend that the city furnish some place for burning it, as that seems to be the only proper manner of disposing of it.

Brookline.

The public swimming bath was open as usual during June, July, August and September. There were 6,573 baths taken in 1894. More commodious quarters, an instructor in swimming and a better water supply are needed.

At the annual town meeting it was voted to appropriate $5,000, asked for by the board, to construct suitable buildings for the shelter and care of persons ill with dangerous contagious diseases, and needing isolation. Under this vote the board, after conferring with competent authorities, had two buildings constructed in one of the least densely populated parts of the town, a safe distance apart and sufficiently remote from all other buildings. The hospitals stand on high ground, in a location of great natural beauty, with plenty of space about them for the erection of tents or portable huts in case of an extensive epidemic. The buildings are of wood, single-story pavilion style, each having three small wards, with a hallway through the middle of the building, a kitchen, cellar and attic, and can together accommodate from twenty to twenty-five patients and attendants. They were planned with special attention to securing ventilation and sunlight, have plastered walls covered with Windsor cement, to permit of thorough and easy cleansing, and all the rooms except the kitchens have open fireplaces. Both buildings have modern sanitary arrangements, public water supply and good piazzas. One of the buildings, the smaller one, is for diphtheria patients, the other for scarlet fever. At one end of the larger building are a kitchen and small ward, wholly separate, and available when necessary as a probationary ward for the observation of any doubtful case. It is often very difficult to make a correct diagnosis at the outset of a case of infectious disease, and meanwhile great danger is sometimes incurred by the family or household with whom the patient may be residing. It is, therefore, a matter of great importance to provide a place for the patient where he will not endanger others if he proves to be infectious, and at the same time avoid the infection of the probationer if his illness proves to be either non-infectious or a less dangerous infectious disease. These rooms will also prove useful at times for laundry and cooking purposes, or for occupancy by convalescents before going among children, or in times of epidemic as a reserve ward. Both hospitals have now been occupied, and have been found comfortable and convenient for patients and nurses. The hospitals can be communicated with by telephone, and are kept always ready for immediate use.

During the summer and autumn a smaller number than usual of cases of malaria were met with in the Holyrood district, and but a few cases in other parts of the town. As a result of the meeting of the Newton and Brookline boards of health, held at Hammond's Pond, Sept. 12, 1893, surveys and estimates of cost were made by the civil engineers of the two municipalities with reference to drying up the swamp land about Hammond's Pond and draining the stagnant pools in that neighborhood. As there has been a decided decrease of malaria in Brookline the past season, the board has not yet asked for any appropriation for carrying out the plans of the engineers, but has served a notice on the parties responsible for the stagnant pools in the Holyrood district that said pools are a nuisance, and must be abated.

The board voted, December 10, that the agent should secure a sufficient number of physicians to make daily medical inspections of the schools. Six inspectors and four substitutes were at once appointed. All accepted, were assigned to schools, and on the 11th all were at their posts. The duties of the inspectors were mainly confined to the examination of children found by their teachers to be ill, and also any noticed by the inspectors, and advice as to the disposal of sick children, and, with very few exceptions, the teachers heartily co-operated.

Report of the Veterinary Inspector and Inspector of Milk.

During the past year we have collected and examined 301 samples of milk, showing an average of 12.83 per cent. of solids, — a remarkable improvement over that of the preceding year.

During the year attention has been called to two horses suspected of being affected with glanders, one of which was condemned and destroyed. One hundred and thirty-one cattle were suspected of being infected with tuberculosis, of which 45 were found to be diseased, and destroyed.

Cambridge.

Total number of complaints and nuisances investigated during the year,		1,617
Number of inspections made,	2,368	
Number of subsequent inspections,	6,163	
Total,		8,531
Number of notices issued and recorded,		1,261
Number of special notices issued,		137
Orders of the board served by constable,		6
Rooms fumigated,		941
Number of notices for treatment of contagious diseases sent out,		1,202
Number of visits to premises where contagious diseases occurred during the year,		2,275
Privy vaults abolished,		632
Total number of free vaccinations at three stations,		1,521

The board directs attention to the necessity of making provision this coming year for proper inspection of the sources of supply of the ice sold for domestic use. Of the importance of such inspection there can be no question. In the absence of such inspection of the source of supply, the chemical examination of a few samples of the ice, which is all that we have at present, is of little or no value as indicating whether or not the ice is unfit for use.

The State Board of Health, in its report on water supply and sewerage, for 1890, Part 1, page 536, says: "In any case an opinion regarding the wholesomeness of a water must be based on all the information obtainable about it. In addition to the chemical and biological examination one should know the location, environment and sources of the water, and the character and population of the drainage area. These facts, drawn from widely different sources, are all interdependent, and help to interpret one another."

So long as the city ordinance relative to ice inspection remains in its present form, our citizens have the right to expect that the examination which the ordinance says shall be made, has been made, and to rely in their use of ice upon its having been made; and we feel the necessity of recommending either that provision be made to enable the duties imposed by the ordinance to be performed, or that the portion of the ordinance relating to the inspection of the sources of supply be repealed, as that portion is at present, in the absence of such provision, more likely to do harm than good.

We earnestly recommend the construction of a sewer to care for the drainage now emptying into Muller's Brook, which will, unless such sewer be constructed, cause a serious nuisance in the near future.

Finding in the locality of Bird's Pond the conditions for the creation of malaria, and the presence of affections which malaria causes, this board does not hesitate to pronounce much of the sickness prevalent there as due directly to the condition of that pond; and we therefore recommend the draining of Bird's Pond and the land adjacent thereto, and the construction of a sewer as proposed by the city engineer to that end.

We urgently recommend that ample provision be made for bacteriological work for the board of health, to detect and prevent the spread of diphtheria.

We have adopted regulations regarding cow stables, embodying the principles which should, we think, be enforced in every stable in the city wherein milch cows are kept. We append a copy of the regulations we have adopted regarding cow stables.

Regulations Regarding Cow Stables.

1. Every building used as a stable for cows shall contain at least one thousand cubic feet of air space for each animal kept therein.

2. The lighting and ventilation, and the condition of the roof and floor, shall be satisfactory to the board of health, and shall be so maintained. There shall be a sufficient supply of pure water, and such other means for maintaining the health of the animals in said stables as the board of health may deem necessary.

3. The stable shall be drained in a manner satisfactory to this board, and wherever practicable shall be connected with the public sewer by a good and sufficient particular drain.

4. The manure shall be kept in a pit, constructed of brick laid in cement, with a concrete floor at least three inches thick, and ventilated as required by the board of health; and no more than one cord of manure shall be allowed to accumulate.

5. The animals shall be examined by a veterinarian approved by the board of health, whenever directed by the board.

6. The premises shall at all times be kept in a condition satisfactory to the board of health.

This board has long recognized the inability of the health authorities of this city to cope with and prevent the spread of contagious diseases, in the absence of any proper provision for disinfecting articles of clothing, bedding, etc., which have been exposed to and may become the mediums of conveying contagion. Realizing this, the board has made strenuous efforts during the past year to have this deficiency supplied. It appeared to the board that the most economical way of disinfecting these articles would be by means of a portable steam disinfecting plant, which could be moved from house to house in the city and might be operated in the street. Such portable plants are in use upon the continent, and one has been designed for the United States marine hospital service. Upon further consideration of the matter, and conference with members of the city government and other citizens, it appeared that there might be objection to the operation of such a plant in the streets of the city, on the ground of the obstruction it might cause and the possible frightening of horses. The board thereupon applied to the Boston board of health for permission to have such disinfecting done at the Swett Street plant in Boston, the city of Cambridge undertaking the carriage of articles to and from this disinfecting plant, and paying the city of Boston a reasonable price for doing the actual work of disinfecting. The Boston board acceded to our request, and our recommendation was then changed to provide for disinfecting these articles in this manner, pending the construction of a permanent plant in this city.

The school committee addressed a communication to the board of health, requesting the board to "appoint a competent physician to examine all cases of contagious diseases in houses in which school children lived, to keep watch of the course of such cases, and to forward promptly to the secretary of the school board notice of the time at which children who have been sick or quarantined may return to school." The school committee and the board of health thereupon joined in requesting the city government to provide such additional funds as would enable this board to

comply with the request of the school committee, which they felt to be most proper. We are happy to state that this provision was made, and that the board of health immediately appointed its medical inspector to undertake this additional work outlined above; and since June 1, 1894, no children are allowed to return to the public schools in these cases except after personal examination of the case by our medical inspector, and upon his certificate that, in his opinion, such return can safely be permitted. To make this plan effective it was necessary to require the certificate of the board of health in every case, and a rule to that effect has been adopted by the school committee. Of the importance of this step, and of the protection thereby afforded to the children who attend the public schools, there can be no question; but, in order to make the system perfect, it should be made applicable to all who attend any school in this city, whether public, private or parochial.

We wish to state our conviction that no attempt at controlling diseases dangerous to the public health will ever be really effectual, nor will the citizens of Cambridge ever be afforded the protection from such diseases to which they are entitled, until the board of health has placed at its disposal ample hospital accommodation for the isolation of such cases as cannot be properly cared for at home, and until a plant for the disinfection of infected articles is provided, and means are supplied for carrying out bacteriological examinations in obscure cases of disease.

When so much is said and written about the influence of schools in spreading communicable diseases, let it be remembered that there are other causes at work equally if not more potent for evil. Little can be added to the forcible words of Clement Dukes on this subject: "In fact, were I asked to name the most likely spots in this country [England] for the starting of infectious diseases, . . . I should not name the market place, the highway, the home, the laundry, the school, the church, the funeral or the theatre, but the public conveyances." Who that has experienced the disgusting stenches and seen the indecent crowding together of men and women in the street cars can doubt the danger of contracting in them nearly every communicable disease to which flesh is heir?

Eight cases of typhoid fever occurred in rapid succession among persons taking milk from the same Somerville milkman. The trouble probably originated at a farm in Bedford whence some of the milk came.

Canton.

We have received but 8 complaints during the ten months since the last election.

We would call the attention of the citizens to the stream which begins just above the Upper Silk Factory Pond. On this stream are three silk mills which have privies emptying directly into it (and this is equally true of all the manufactories and most of the dwellings that are situated on the

borders of brooks and ponds of the town), so without exaggeration it is safe to say that more than five hundred persons use this stream daily for a common sewer. This stream has formed a bar or bank several feet in depth, which at high water is covered by scarcely eighteen inches of water, while in the summer when the water is low it is bare a large part of the time and exposed to the scorching rays of the summer sun; and this is in the heart of the village, and within a stone's throw of the largest if not the principal school-house of the town.

Concord.

In the fall we suffered, in common with a great many other places, from an unusual amount of diphtheria, there being twelve cases reported between the 9th and 27th of November. Since that time the number of cases has rapidly diminished, and at the present time, March 1, there is but one case that we know of in town, and only three cases of scarlet fever. At the first sign that the above diseases were liable to become epidemic we passed a regulation, as printed in last year's town report, requiring all children absent from school on account of sickness for two consecutive days to bring a doctor's certificate stating that they were not suffering from any contagious disease, or to remain away six weeks. We are of the opinion that that regulation did a great deal to stop the spread of the disease; and we know, from the teachers, that it helped to increase the attendance at school greatly. The great danger (and we cannot emphasize this fact too strongly) lies in the fact that a scholar may be suffering from a mild attack of scarlet fever or diphtheria and be kept out of school a day or two and then sent back in the very best time to spread the disease. The parents, not having called a physician in, are not aware that their child has anything more than a cold, and in that way the disease is spread more than in any other.

The agent fumigated 44 different houses.

The one matter of keeping swine in the village gives the board more trouble and bother than any other. In one case we were forced to bring suit.

The inspector of provisions and animals has reported to this board that he has at various times quarantined sixteen cows that he suspected were suffering from tuberculosis.

Cottage City.

A contract was made for cleaning cesspools and vaults, also a contract for the collection of swill and garbage. Two hundred and sixty-three orders have been received for removing the contents of cesspools and vaults, 38 permits were given for various purposes and 1 license granted to a master plumber.

At a special meeting of the town a vote was passed asking the board to remove the unsightly vegetable growth from the waters of Sunset Lake. An additional appropriation was made for this purpose.

DEDHAM.

Compared with the preceding year and for a number of years previous, the number of cases of contagious or infectious diseases will be seen to have been very small. During the preceding year, 1893, 53 cases of scarlet fever and 47 cases of measles were reported. The records this year are 5 for scarlet fever and 3 for measles. All cases of typhoid fever reported this year came close together, and the board made investigations to see whether any specific cause could be assigned for such cases. A large number of the cases were found to have been contracted probably outside the town. Dedham has an excellent supply of drinking water in the public system, and continued analyses made by the State Board of Health have shown no cause for alarm in this direction. The question of drainage is a matter which must face the town at a very early date, and no question of greater importance to the public health and welfare of Dedham exists.

The tabulation of death records recently prepared by Mr. Hill, town clerk, from 1844 to 1890, extending over a period of forty-five years, shows that 877 deaths were from consumption alone, out of a total of 4,915 deaths from all causes.

The board believes that there is no question before the town of such vital importance regarding its general health and welfare as that of sewerage. The town should, at a suitable time, see that its interests are amply protected and subserved by any plan which may be adopted for the construction of a trunk sewer. Especially is it desirable that such trunk sewer shall provide ample means of draining all portions of the town limits which are in any way liable to need a sewerage system in the next thirty years, and such main sewer should also provide ample capacity for taking care of this sewage with that obtained from other locations.

More or less complaint having been heard in regard to the jail sewerage, the board had analyses made of the effluent water from the disposal field. These analyses were made by the State Board of Health; their results showed absolutely no trace of contamination from the filter beds, and the board believes that the disagreeable features which are noticed from time to time proceed from other causes.

EAST BRIDGEWATER.

The board has examined and corrected a great many nuisances during the past year, and some which were corrected last year were found in a bad condition again this year. They were again corrected.

Scarlet fever has appeared in two outbursts this year, but through the whole epidemic the disease has run a mild course, and no deaths have been reported.

We have organized a board of plumbers, according to law, and have licensed one to do the plumbing in this town.

About 100 school children were vaccinated, as a part of the work of the board, this year.

EASTHAMPTON.

During the year there has been much improvement in the general health of the town. There has been no epidemic of disease, other than scarlet fever, which has prevailed in a very mild form and has caused no deaths.

We would recommend the construction of a small building near the buildings now on the town farm, to be used as a village hospital in cases of contagious disease. Such a building would not necessarily be very large or very expensive, perhaps one story high and with two or three rooms. It should be made pleasant and attractive, without and within, to the end that the sufferer might not be needlessly depressed by disagreeable surroundings. Such a building would do away with the unpleasant associations that surround the name "pest house," and would be found a very useful and economical provision when its use should be required.

EVERETT.

Ninety-one houses have been fumigated. In many cases where scarlet fever has been in a mild form there has been great difficulty experienced in keeping the patient isolated, or even in-doors, until danger of contagion is passed.

The board in November adopted the method of taking cultures in diphtheria cases. The physicians have gladly co-operated with the board in this work. We have been very fortunate in having so few cases of this disease, considering its marked prevalence in Boston and other neighboring cities.

We have also adopted a card for the admission of children to the schools, which reads as follows: —

> This certifies that   may safely be admitted to school after   , 1895 [signed by representative of the board]. Keep this card and give it to the teacher after above date.

One of these cards for each child that attends school is left at the house at the time of fumigation, the date of safe admission is written upon the card, which is, according to the statute of the State, two weeks later. The school teachers will not admit scholars who have been out on account of contagious diseases unless one of these cards is presented. Before the adoption of this method we found that some out-of-town physicians gave certificates of recovery that would admit children to school who were in just the stage to spread disease.

We propose to have every house that has been vacated by a consumptive family thoroughly cleansed before it is again occupied. This method has been employed in New York for over a year, with good results.

Fall River.

The comparative freedom of the city during the past year from contagious diseases is a condition upon which the citizens can well be congratulated.

The prejudice at first manifested by householders against having their houses placarded, we are pleased to state, is fast disappearing, in proportion as the object for which it is done is becoming better understood.

Owing to the prevalence of small-pox in several cities during the past year and the notices in relation to vaccination published by the board, a larger number has been vaccinated at this office than in any preceding year. The number vaccinated in 1892 was 1,326; in 1893, 1,231; and 1,720 during the past year.

Sixteen horses affected with glanders or farcy were reported to and quarantined by the board during the year. Eleven cows were reported as having tuberculosis, and were placed under quarantine and the Cattle Commissioners notified. All but two were condemned and killed and disposed of otherwise than for food.

For the year ending Dec. 31, 1894:—

Number of live cattle examined,	1,206
Number of live cattle examined and reported diseased,	6
Number of meat carcasses examined at slaughter houses,	500
Number of meat carcasses examined and destroyed,	50

Fitchburg.

The recent law enacted for the inspection of plumbing under the direction of the board of health makes it possible to exercise a careful watch over the construction and reconstruction of dwellings so far as their sanitary condition is concerned, and in a way which will ultimately make such conditions the best possible to be obtained. With this possibility in view, it was deemed a most favorable time to begin the work of remedying as fast as possible those unsanitary conditions in old constructed dwellings which so often prove to be the cause of physical degradation and disease. By a systematic plan of recording all the facts obtained by this inspection and a carefully prepared index to the same, it has been possible to accomplish a great deal. Information has been thereby furnished on matters of local sanitation and house drainage which will help greatly in the future improvement of certain sections of the city, and in the solution of problems concerning the extension of our sewerage system. The work has not met with any serious opposition, and in many cases has been materially aided by the co-operation on the part of property owners and members of the medical profession. Many of the latter have asked the help of the board, and have availed themselves of the facts obtained by this method

of investigation for the benefit of their patients. The work has divided itself into the regular house-to-house inspection in sections of the city where poor sanitation was reasonably to be expected; the inspection of every house where any disease dangerous to the public health was reported; the inspection of houses where suspicious cases were reported and an inspection requested by physicians; and the inspection made by reason of nuisance complaints.

Total number of inspections recorded,	504
Number of dwelling-houses inspected,	441
Number of dwellings and stores combined,	33
Number of separate stores,	8
Mills and workshops inspected,	9
Public and other buildings inspected,	3
Separate barns and stables inspected,	15
Number of separate tenements inspected,	1,038

The distribution of scarlet fever during the several months has something of importance, not so much with reference to the climatic conditions as with reference to school attendance. Fifty of the 66 cases were reported during term time, 16 during vacation. Counting the actual time when children are in school and the time when the schools are not in session, it is found that the prevalence of this disease was a little more than twice as great during term time as during vacation time. The largest number occurred during the April to June session, namely, 27. The next largest number occurred during the September to December session, 18 in all.

In dealing with contagious disease, it is often a difficult question how to secure a proper isolation. Without such isolation much of the work attempted by a board of health as regards school attendance, disinfection and other matters, seems in the minds of many extremely foolish. Often the rules of the board do not actually accomplish what they aim to accomplish. They fail in the direction of not sufficiently protecting the public at large, by reason of not providing an efficient isolation during the period of danger. Theoretically, it is possible in nearly every instance to ensure a good degree of isolation in cases of contagious disease, whether mild or severe, but practically, it is often impossible without causing additional suffering and danger to the sick, or great inconvenience and expense to those too poor to incur the same. To properly deal with this class of diseases a hospital is greatly needed, suitably arranged and located so that any case can be at once removed from all danger of communicating any contagion, and kept under close observation until all danger is passed. It is earnestly hoped that in the near future Fitchburg will have a hospital for contagious diseases, as she now has one for the treatment of other forms of sickness. This can be brought about by the board, when the public safety demands it, under the provisions of a recent statute.

Framingham.

The board would recommend that the town provide a house suitably furnished for the reception of persons suffering with contagious diseases, who have no home and cannot be otherwise provided for. Such a case happened in Saxonville last November, and the patient was taken to the home of the member of the board of health from that place and cared for during an attack of diphtheria.

Very few written complaints have been sent to the board the past year, but those few have been attended to in every instance.

Soon after organizing, we adopted the system used by the city of Worcester, of notification of contagious disease to the board from the physician attending; from the board to the teacher of the school which the child attends; also from the board to the librarian of the town library. We had printed and forwarded to the teachers of the schools instructions in regard to contagious diseases, and also instructions to the family where the sickness occurs. When a child recovers the teacher is also notified, and when the two weeks which the statutes require shall have expired, when the child can return to school.

Franklin.

At our first meeting, in compliance with the requirements of the law, we licensed the plumbers and appointed an inspector of plumbing; also an inspector of the meat and provision markets and at the slaughter houses.

Our inspector of animals has reported the following contagious cases: tuberculosis in cattle, 26; glanders in horses, 3. These animals have been destroyed in the manner required by the law.

Gardner.

The board of cattle inspectors has during the year examined 1,011 head of cattle. Of this number 6 have been found to have tuberculosis, and were killed according to law. Some member of the board has also been present at the killing of 24 head of cattle for beef. Of this number, 2 have been condemned and destroyed.

Gloucester.

The board calls attention to the need of public parks for Gloucester, and suggests certain localities appropriate for such purposes.

There is need in the city for a hospital for contagious diseases, that is, for the ordinary "catching" diseases of children. To illustrate this, let us instance a family which depends for its support on the exertions of the mother, that is, in the main; a case of scarlet fever breaks out, and the mother is practically quarantined; other cases break out, and perhaps six or eight or even more weeks have passed before the mother can resume her

work. Now, it may happen that the families which employed her have secured other help, and to get it have been obliged to promise that they would not discharge the new help if their work was satisfactory. It will be imagined to what a condition the family which has had the visitation of scarlet fever has been reduced by the total suppression of income and the loss of positions where they have formerly performed housework; many who generally manage to support their families in part or wholly are obliged to seek aid of the city.

Greenfield.

The regulations of the previous year were adopted, with the addition that the keeping of swine within the thickly settled part of the village should be restricted. This order was received with a good deal of disfavor by many, as infringing upon the rights of individuals; but in our opinion it is impossible for swine to be kept in a thickly settled community without their presence becoming a nuisance at certain times of the year, and we feel it would have been better if the order had been prohibitory rather than restrictive.

As an additional safeguard against the spread of all forms of contagious diseases, in the opinion of this board, the medical inspection of our public schools is most desirable.

Under date of Feb. 15, 1895, circular letters containing the following questions were sent to the resident physicians, with the request that they favor the superintendent of schools with answers thereto. As a result of this inquiry, the superintendent made the following recommendations: (1) that the use of slates in the schools be discontinued; (2) that the floors and furniture of the school-rooms be washed once each term; (3) that the board of health be consulted in regard to the best means of sterilizing books; (4) that a sum of money be raised and appropriated for the medical inspection of the schools, and that the board of health be consulted as to the frequency and general plan of inspection.

Haverhill.

Most of our physicians perform the duty of certifying the causes of death with great care, skill and exactness, while others, having little knowledge of the use and value of mortality statistics, are not always careful to make their returns full and accurate. It is a common thing to find on death certificates such indefinite information as "meningitis," "convulsions," "debility," "loss of strength," "exhaustion," "disease of lungs," "disease of brain," "stomach disease," "hemorrhage," "dropsy," "infantile," "inflammation," "septicæmia," "heart failure," and many other indefinite causes. Correct mortality statistics cannot be secured from such worthless certificates, and they ought never to be placed upon the registrar's records as causes of death.

Complying with a request of this board, the city solicitor has recently submitted his opinion that, in the absence of hospital accommodations, the board of health has no authority, under sections 40, 41, 43, 44, 45, 46, 47, 48 and 75 of chapter 80 of the Public Statutes, to quarantine persons in houses in which diseases exist which are dangerous to the public health, and in this opinion it will be seen that he is sustained by recent decisions of the supreme judicial court; nor has the board, by a ruling of the local court, before which a test case was made last summer, any authority to make and enforce regulations (under section 18 of chapter 80) quarantining persons sick with diseases dangerous to the public health. To the absence of such power is attributed the increase in the number of cases of scarlet fever the last half of the year.

Hudson.

Though the town has a plan for a system of sewerage, with estimates of cost, the great fire of July 4 last has entailed so much extra expenditure on the part of individuals, as well as the town, that it is doubtful whether it is advisable to begin its immediate construction. If not begun, greater precautions than ever will be necessary, on account of each year's added filth to the surface soil, especially in the more thickly settled portions of the town. All privy vaults should be emptied as often as twice each year, — by the first of May and the first of November; and after each removal, dry earth, or dry ashes free from all fire, should be thrown in, in sufficient quantity to absorb all moisture, and new applications of dry earth or ashes applied as often as once each week, or oftener.

Hull.

The sewers of the town are in good condition. During the summer months they were flushed twice a week and kept in good order. The board would recommend the construction of a small piece of sewer on Stony Beach, Nantasket. It would receive the sewerage from some fifteen houses, and thereby abate a nuisance which now exists in this locality. With few exceptions, all residences located on thoroughfares where there are public sewers are connected therewith.

The new plumbing regulations have been in force since Sept. 1, 1894. An inspector has been appointed, as required by law, and all plumbing or sanitary improvements are made under his supervision.

Hyde Park.

Owing to the complaints of many of our citizens, the board thought best to make a change in the manner of clearing vaults and cesspools. The attention of the board was called to the work done by the apparatus known as the "odorless excavator," and after a thorough examination this method was adopted.

Early in the year, to conform to the laws of the State, the board took up the matter of the appointment of an inspector of plumbing. Applications were received from several for the position, which was finally decided by civil service examination, and given to the one who received the highest per cent. in rank. Afterward the board appointed an assistant.

Nearly one hundred complaints have been investigated, and most of the places have been attended to.

Ipswich.

Excepting a slight epidemic of diphtheria in the month of August, during which most of the deaths occurred from that disease, the contagious diseases have been in a very mild form.

The sanitary condition of the town, we think, will compare favorably with any town in the State of its size. We have not had to resort to any legal measures in regard to the abatement of nuisances, and the people have taken kindly to our regulations and assisted us in every way in their power.

Lancaster.

But few cases of contagious disease have been reported, but a mild form of influenza has been quite prevalent during the winter. In consequence of the prevalence of diphtheria in neighboring towns, the board has thought it wise to be equipped with a supply of antitoxine sufficiently large for use in any case until more can be procured, for which arrangements have been made at the laboratory where it is manufactured. Instruments necessary for the proper administration of the remedy have also been procured, so that none may suffer from delay in procuring the proper remedy in this terribly contagious disease.

The board has continued to have analyses made from time to time of the river water, with a view to keeping posted as to what degree of pollution is sustained by the Clinton sewage flowing into it.

Lawrence.

The earnings from removal and sale of night soil have steadily decreased since 1888, at which time the board began to order vaults to be abolished and replaced with water-closets. In 1888 the department cleared seventy per cent. above expenses on this branch of the work, while at the present time there is a loss of twenty per cent., and the revenue will continue to grow less as the vaults are replaced with water-closets.

Eight teams and sixteen men are required for the collection of garbage, which is deposited at the several dumps, a method of disposal that is not only objectionable, but a nuisance. There were 19,500 loads of garbage collected during the year.

The cleaning of private cesspools requires the whole time of one team and two men. It is necessary, from a sanitary point of view, that these

cesspools be abolished and proper sewerage provided. There has been an alarming amount of sickness in these localities, which would be considerably lessened if the cesspools were abolished.

The board does not advocate cremation as the only way of disposing of the refuse, but, knowing the exact condition of affairs, — that we have 25,000 cubic yards of garbage and 450 cords of swill to be disposed of yearly, with no proper sanitary way of doing it, — we consider it is absolutely necessary to dispose of the waste matter in some proper sanitary way other than the method now in use. Some method should be adopted that would wholly destroy it, and we trust that the city government will enable us to adopt a satisfactory way of disposing of the waste matter. The waste paper, which formerly was used by the paper mills, is now collected by the department, and forms a very large portion of the refuse collected. It is a nuisance at the dumps, as it causes frequent fires, which are the cause of much annoyance to those who live in the vicinity, and if it is not burned, it is very objectionable to mix it with other refuse.

That the method of the water board of providing the city with pure water has been the means of our city escaping a severe epidemic during the winters of 1893–94 and 1894–95 is plainly evident, and the citizens cannot be too grateful for the change. Below is given a list of the cases and deaths in Lowell and Lawrence: —

Table of Cases and Deaths from Typhoid Fever in Lowell and Lawrence.

	Cases.		Deaths.	
	Lowell.	Lawrence.	Lowell.	Lawrence.
January,	99	9	13	2
February,	60	19	19	6
March,	33	17	5	4
April,	9	1	1	–
May,	11	5	3	2
June,	2	3	1	–
July,	4	4	3	3
August,	13	3	1	2
September,	7	10	3	3
October,	21	15	–	1
November,	14	4	1	1
December,	19	2	–	–
Totals,	292	92	50	24

In February we had one case of small-pox, a child ten months old being afflicted with the disease. The case was confined in the house where it originated, and the inmates quarantined for one month during the existence of the case.

The number of master plumbers, employers and journeymen, are as follows: employers, 20; masters, 11; journeymen, 33. Licensed sewer contractors, 8.

The following table shows the work in detail for the year: —

Jobs accepted,	444
Water tests,	477
Number of inspections of plumbing work done in old and in new buildings,	2,852

Lee.

During the year the board ordered a general vaccination, providing the virus and free vaccination to all unable to pay.

Regular investigations of premises were made, and many complaints pertaining to imperfect drainage were attended to. With our imperfect system of sewerage it is impossible to avoid the difficulties arising from drainage.

Leominster.

The sanitary condition of the town is very much improved, through the efforts of the board of health. A very noticeable decrease in the number of contagious diseases shows it. There have been only 69 cases in all reported during the year, against 323 for the year 1893.

During the year 120 nuisances have been discovered and abated, and 30 cases of scarlet fever and 5 cases of diphtheria have been flagged. In 15 cases of measles and 8 cases of typhoid fever cards have been placed on the houses where the disease existed, announcing the fact to the public.

All cases of contagious diseases have been reported to the State Board of Health and to the school committee of Leominster, and a record of all such cases has been kept in the office of the board of health.

Lowell.

During the year 1894, 29,679 loads of ashes were removed from houses and stores to the various dumping grounds in use. The total number of vaults removed in 1894 was 145.

The most important question that was solved by the erection of the cremator was the disposal by burning of such a large proportion of swill and market refuse as had been before thrown upon the dumps, that should receive only clean ashes and paper refuse. The time will come when the city must have an outlet for all its swill and refuse, without recourse to the pernicious system of feeding to swine. But Lowell is now in a much better condition, with its present small cremator, than any other city in New England; and when any other furnace or rendering establishment can convince the board, by as careful and trustworthy record of actual results as has been applied to the Lowell furnace, that they can dispose of the gar-

bage at a less cost and in as clean and sanitary manner, they will gladly recommend its adoption and erection by the city. Experiments have been made at different times with the ash product of the furnace, and 50 tons have been disposed of at a price. There have been no complaints, but, on the contrary, a great many expressions of satisfaction from citizens of Lowell, that by its operations so many thousands of tons of perishable matter have been disposed of by such a cleanly and sanitary method. The garbage burned at the cremator during 1894 was as follows: —

Swill (tons),	3,066
Market refuse (tons),	420
Infected clothing (barrels),	12
Infected night soil (ton),	1
Dead animals (about),	350
Largest week's work,	186,145 pounds, = 93 tons.

From an inspection of tenement-houses in the city of Lowell, covering years, it is the unanimous opinion of the board that the stingy use of metered water in the city is greatly to be deplored. Because of a desire to keep the water bills at as low a point as possible, the owners of tenement-house property very often shut off the water at nightfall, and before it is let on again in the morning many people have been obliged to get their hasty breakfast and commence work in the mills without the convenience of water either at their sinks or water-closets. The question of the health of the poorer class of tenants in some of the dilapidated buildings in the city is of more importance than any system that continues and increases the danger, even if the theory is correct that the universal use of meters may save a few paltry dollars in the cost of pumping the sewage-laden water of the Merrimack River.

To assist in making the diagnosis in mild cases of throat and nasal troubles, as well as to decide when a convalescent diphtheria patient became free from contagion, the board decided to furnish the physicians with the bacteriological diagnosis of diphtheria. Quarters were obtained in the milk inspectors' laboratory, and a graduate of the Harvard Medical School, who has studied bacteriology there and abroad, was appointed bacteriologist to the board. There have been fewer deaths from typhoid fever than in any year since 1885. The fact that more cases of the disease were reported than in 1893 does not necessarily show a great increase of the disease, but perhaps indicates that at last physicians are beginning to report this disease with the same promptitude that they do the more directly contagious diseases.

The water board is to be commended in its extension of the driven-well system, but the supply from the river should also be filtered. The mortality from typhoid fever will not be greatly reduced until the whole city is supplied with pure water, *and can use it freely.*

A detailed statement of 8 cases of small-pox is presented in the report. Immediately upon being notified of the existence of a case of small-pox, all the family and others likely to have been exposed were vaccinated. On December 26 the office hours at the city hall were increased, being from 4 to 5 P.M. and 7 to 9 P.M. week-days, and also on Sunday afternoon. So great was the number of applicants that finally three sets of physicians were employed, each with two assistants, one to prepare the arms and apply the dressing, the second to register the name, age and residence. Ten thousand people were vaccinated at the city hall while the outbreak lasted. On the day after the disease made its appearance an office for vaccination was opened in the infected district, with hours from 12 to 1 and 7 to 8 P.M. This was closed January 7. Also at the beginning of the outbreak the manufacturing corporations were requested to vaccinate all their employees who had not been successfully vaccinated within five years; about 8,500 were thus vaccinated in the mills. On the appearance of another case of small-pox, on January 2, house-to-house vaccination was begun in the infected district. There were 26,685 cases of vaccination in a city of 90,000 inhabitants, a large proportion for a city of this size. Next to vaccination, the most effective method of preventing the spread of small-pox was by separation of the sick from the well. When a patient was removed to the hospital, such articles of clothing or bedding as could not be disinfected by boiling were taken to the cremator and burned. The sick-room, after exposure to the fumes of burning sulphur for several hours, was thoroughly aired, and then the woodwork and furniture were scrubbed with a one to five hundred per cent. solution of corrosive sublimate. In some cases the ceilings were whitewashed and the rooms repapered. The board of health did not feel justified in placing entire reliability on disinfection by sulphur. Had the city possessed, as it should, a steam disinfecting plant, many articles that were destroyed could have been saved. Although destruction by fire is an expensive method, when articles have to be replaced, yet it is without question the safest method for the destruction of disease germs. It was felt best here in Lowell to place a strict quarantine in most of the infected houses for a fortnight after the removal of the patient to the hospital. By this means the disease was confined to one locality.

LYNN.

The garbage scow has made 14 trips during the year, carrying and dumping 1,272 tons of vault and cesspool matter and 286 tons of house offal. There is no other sanitary method known to us by which our product can be disposed of at so small an expense, therefore we deem it wise to continue the present method of its disposition.

A parcel of land of about four acres, on the north side of Holyoke Street, was selected as the site for the hospital for contagious diseases. Since then

the committee on public property has adopted plans, let the contracts for building, and the plant is now in such an advanced stage of completion that it will be ready for occupancy within a short time.

Certain brooks and a mill pond in Lynn, which were in a filthy condition, were made the subject of complaint by neighboring citizens, and finally the Legislature acted upon the question, the act being chapter 302 of the Acts of 1894, entitled "An act to abate the nuisance caused by the dam on Little River in the city of Lynn." No action was taken under this act. Stony Brook was afterward complained of, and after a hearing and as the result of the hearing and investigation the brook was declared to be a nuisance and ordered abated. Since then the brook has been straightened, widened and cleaned out, the pond water drawn off, and the city has expended a large sum in street and bridge repairs, affording a sufficient and unobstructed flow of water.

The milk inspector took and caused to be analyzed 3,295 samples of milk. Of these, 1,638 were taken from milk teams, 908 from grocers and 749 from the cars and dairies; 322 samples were below the standard. Twenty-one cases were brought into court; 17 of these were for first offences, 3 for second offence, and 1 for third offence. Convictions were secured in all of the cases; 15 paid their fines, 4 were placed on file, 2 appealed and their cases are still pending.

He goes on to say: "During the year I have, by rigid inspection of cattle, meats and provisions, endeavored to remove as far as possible all conditions that were conducive to disease, either by the sale of decomposed meats, fruits or vegetables, or by the use of sick or suspicious cows for the production of milk. One hundred and eighty-three complaints have been attended to. Thirty-seven barns have been inspected, several of which, being in a filthy condition, I have caused to be cleaned and rendered fit for use. I have condemned and caused to be destroyed 168 pounds beef, 230 pounds corned beef, 34 pounds veal, 38 pounds pork, with a considerable quantity of other meats, fruits and vegetables. There have been 1,581 head of cattle inspected; 19 head of cattle have been quarantined; 7 head of cattle have been killed."

The total number of inspections of all kind for the year, by sanitary inspectors, were 5,025.

Malden.

Complaints have been numerous, and, as in previous years, largely arise from overflowing cesspools and vaults. This condition of things must, we suppose, continue until the sewers are ready for use. We hope and believe the present year will see many of the worst localities connected with the system of sewers, and thus enable the board to require the abandonment of cesspools and privies, where they are now and must continue to be a constant source of annoyance and complaint.

The board would still urge upon the city council the need of a contagious ward that would be wholly under the control of the city. The necessity for such a ward becomes more pressing as the city increases in population.

Marblehead.

The board has received 44 complaints, many of which were occasioned by the annoying and unhealthy odors from pig-sties in too close proximity to dwelling-houses. For the protection of the public health, we would recommend that no person be allowed to keep pigs within five hundred feet of any dwelling-house.

Too much emphasis cannot be laid upon the importance of keeping the drains of the town in good condition, for without good drainage we cannot hope to be a healthful community.

Marlborough.

During the year the board has not limited its work to the removal of causes of complaints, but has endeavored to consider and investigate any subjects relating to the health of the city which have been brought to its attention. In all there were abated during the year 276 nuisances.

A mild case of small-pox or varioloid was reported to the board January 16. The city council voted to furnish money to vaccinate all children whose parents desired to avail themselves of free vaccination. Seven of the town physicians were employed, and in four days nine hundred of the scholars were vaccinated at the city's expense. The other children of the schools were inspected and required to show satisfactory marks of recent vaccination.

For account of Professor Sedgwick's investigation of epidemic of typhoid fever in Marlborough, see pages 765–774. The board of health of Marlborough, in behalf of the citizens and for themselves, is most thankful to the State Board of Health for this investigation. It was carefully and rapidly made by one thoroughly familiar with this kind of scientific work, and the conclusions arrived at dispelled the fears of danger from the water supply and certain other possible sources of contagion.

There were 269 specifications for plumbing filed at this office, 186 for new plumbing and 83 for alterations and additions. The alterations in many cases consisted of the entire remodelling of the plumbing, the work being done in accordance with the rules of the board of health. These rules require plumbers to register at this office, and, before proceeding to construct or to add to or to alter any portion of the drainage system of buildings, to file plans of the proposed work. The plans must show the whole work in detail and meet with approval before they are accepted and a permit granted to proceed with the work. During the progress of the work each job is efficiently tested by hydraulic pressure to insure good

material and effective workmanship. Frequently as the work advances visits of inspection are made. During the year 235 hydraulic pressure tests and four peppermint tests and more than 500 miscellaneous inspections have been made.

Maynard.

Through the efforts of the board, the drainage of certain portions of the town has been much improved.

Medford.

There have been 185 nuisances reported, all of which have been satisfactorily abated.

Melrose.

An important element in the spread of contagious disease is, in case of an infected household, the frequent and exasperating indifference with which the residents of the house mingle with the neighbors and the community. Cases came under our observation where members of a sick family would stroll leisurely from the sick-room directly to the stores, mingling with the people there and along the streets. So serious and notorious had become this wanton neglect in so important a matter, that the board had a large number of circulars printed, of which the following is a copy, one or more of which was taken to every infected house by the officer who posted the card: —

Office of the Board of Health, Melrose, May, 1894.

To the Householder.

During the present sickness in your house your children are not allowed to attend school till a certificate is given by your physician. Children and other members of the family are not to mingle with other persons unless *absolutely* necessary, and then only under precautions given by your physician. No visitors must be allowed, and every care must be used not to spread the disease. Any violation of these rules involves a severe penalty.

At the close of this sickness the law requires that the infected rooms and objects be thoroughly fumigated. This will be done at the proper time under the control of the board of health.

By order of the

Board of Health.

The amount of sickness from contagious diseases during the past year, 121, was notably less than during the previous year, 205.

Milford.

This year the attention of the board has been called more especially to the want of care paid house sewerage. In a number of cases we have been unable to reduce nuisances without appealing to the laws governing such cases; even with this help we have found ourselves decidedly handicapped.

Millbury.

The public nuisance caused by the sewage of the city of Worcester in the Blackstone River continues unabated, and the consequent inconvenience, discomfort and danger to the public health remain practically as for some years past. It is the almost unanimous opinion of those persons best informed, as expressed to members of this board, that at no time has the stench from the river been more offensive than at times during the past summer. During the month of September the attention of the board was called to the polluted condition of the river by parties employing a large number of women. Our investigations elicited testimony that the stench from the river has been worse during the past season than ever before, and that operatives have been so nauseated and sickened by it as to force them to quit work.

The number of neat cattle inspected in the spring was 706. During the year the inspector has discovered and placed in quarantine 5 cows affected with tuberculosis. These animals were killed, and an autopsy showed each of them to be badly diseased. Three cases of glanders in horses have occurred, and the animals were killed.

Nahant.

The general health of the inhabitants of the town was comparatively good. There was no epidemic disease and only two cases of typhoid fever in town.

Nantucket.

The town has been remarkably free from contagious diseases.

Natick.

Never since this board has been created independent of the selectmen has there appeared such willingness on the part of our people to comply with exacting sanitary regulations, and this feeling has materially lightened the burden of our duties. Complaints for poorly constructed drains, vaults, cesspools, etc., have been numerous, and as a rule these difficulties cheerfully remedied after inspection and citation.

A set of plumbing regulations was drawn up by the board and submitted to the town for adoption.

Needham.

During the appearance of small-pox in certain of our neighboring cities an effort was made to ascertain the number of unvaccinated children attending our schools; as a result of this investigation by the health officer, assisted by the teachers, between seventy and seventy-five pupils were found without evidence of vaccination. Feeling that at least our children should all be vaccinated as the law requires, and owing to the straitened circum-

stances of many of our citizens, who could not afford the expense and who were compelled to take their children from school, at the suggestion of prominent citizens and by vote of the board vaccination was made free to all pupils of the public schools who had not been successfully vaccinated.

We have investigated all complaints made, and acted according to our best judgment.

New Bedford.

Voted, That the order of Oct. 14, 1893, be amended so as to read as follows: —

To make the following addition to the list of diseases in the opinion of the board dangerous to the public health, within the meaning of chapter 80, section 79, of the Public Statutes: measles, whooping-cough, membranous croup, typhoid fever and typhus fever.

Voted, That the board assume expense of all tests for diphtheria where patients are unable to pay the costs, such patients to procure certificates from the overseers of the poor.

During the year each case of typhoid fever that has been reported to the board of health has been thoroughly investigated. We believe that the comparatively small number of cases of typhoid fever reported this year has been in a measure due to the precautions taken by the board.

Newburyport.

We have had very few cases of contagious diseases the past year, with the exception of scarlet fever, which shows an increase of 4 cases over last year, which speaks well for the sanitary condition of the city. Last year we had 55 cases of diphtheria and 57 cases of typhoid fever.

The board of health publishes a code of plumbing regulations, and, unless the board shall authorize variation by special permit, on request of the owner, the drainage system of a hotel, tenement-house, dwelling-house, stable with sleeping apartments, factory, shop or other buildings in the city of Newburyport shall be constructed according to these rules.

Newton.

The health of the city has been about the same as the average, a slight increase of scarlet fever during the first quarter, an increase of diphtheria in the last quarter and some malaria and typhoid fever during the late summer and early fall being customary.

The collection of garbage has been made by contract. The contract requires collections to be made three times a week between April 1 and November 1 of each year, and twice a week between November 1 and April 1.

The board has visited the cities of Philadelphia, Pittsburgh and Alleghany City, Pa., Wilmington, Del., and Atlantic City, N. J., and inspected the practical workings of five different systems of garbage disposal. The subject is now under consideration by the board, and will be made the theme of a special report.

Action has been taken by the board looking to the abatement of 58 nuisances of various kinds, and many others have been abated at the request of the agent without action of the board.

The contagious wards of the Newton hospital have again demonstrated their usefulness, and the board has been enabled, by sending patients there in the early stages of disease, to remove a source of infection and prevent its further spread.

The question of closing a school when a number of cases of contagious disease occur among the scholars is one to which the board has given much thought. A great deal can be said on both sides; but, upon the whole, the board is opposed to closing a school except under extraordinary conditions. The plan pursued by the board has been to close the school temporarily, and, after disinfecting it thoroughly with sulphur and corrosive sublimate, to allow it to be reopened. As a further precaution against infection, the board has made the following suggestion to the superintendent of schools, *i. e.*, that he should request all teachers to dismiss from school any pupil who may seem to be ill, and promptly notify the board, giving the name and address of the pupil so dismissed. On receipt of such notification the board will have the child examined and a report of its condition made within twenty-four hours. In this way the child can be isolated if necessary, or allowed to return to school with the least possible delay. This rule will hold good at any time, whether there are cases of contagious disease among the scholars or not. This action is in no way intended to interfere with the prerogative of the family physician, as the physician sent by the board will simply report upon the case, and, if necessary, advise that the regular medical attendant be called in. In no case will the board's physician be expected to treat the patient to whom he may be sent.

The board is establishing stations throughout the city where physicians can obtain culture tubes, and by leaving the specimen at the station it will be examined, and a report returned at the earliest possible moment.

Light cases of scarlet fever are often unnoticed by parents or no attention is paid to them, and they pass as a slight "cold" or mild attack of "sore throat," and are treated with domestic remedies. One such unrecognized case occurring during recess or while school is in session may expose all the children in a school to the disease, and the first warning the board receives is when the reports of other cases reach the office. By that time the mischief has been done, and all the board can do is to try to discover the source of the disease and prevent its becoming epidemic.

The ideal method to prevent such a danger is to have a medical inspection of the school children every morning. This is of course at present impracticable, although it would be possible to have it done before the reassembling of the children after the summer vacation and after each break in the school work lasting more than one week. Such an inspection in all probability would have prevented the two outbreaks referred to and saved the lives of the unfortunate victims in the Rice school.

It is an undoubted fact that malaria has been on the increase during the past few years, not only in Newton but in the surrounding cities and towns; but it is a mistake to suppose that there has been any marked increase in Newton during 1894. At the close of the season, when the increase if it existed would have made itself manifest, the board addressed a circular letter to the physicians of Newton, asking whether they had noted an increase in the number of cases of malaria over the corresponding season in 1893, and, if so, what in their opinion was the cause of it. Out of twenty-three answers received by the board, sixteen stated that they had noted no increase. In the opinion of those who had found an increase, this was due to two factors: first, the lowness of the water in the Charles River and the consequent exposure of large quantities of decaying vegetable matter; and, second, to the turning up of large areas of fresh earth from the various improvements going on throughout the city. The conclusions arrived at by the board was that the statistics for 1894 show no more increase than would naturally be expected from the growth of the city during the same time, and, further, that the relative increase is less than in previous years.

Only 29 cases of measles were reported during the year, against 548 for 1893.

Northampton.

The work of permanently improving the sanitary condition of the city by requiring that dwellings situated on the line of the public sewers shall be connected with them has received the greatest share of the attention of the board this year.

The board would draw the attention of the city council to the need of a proper hospital for the treatment of contagious diseases, of a place to bury dead animals and of a proper dumping ground for the disposal of rubbish.

North Andover.

At a special meeting, held Jan. 8, 1894, it was *Voted*, That all school children who have not been duly vaccinated should be immediately vaccinated at the expense of the town.

Promptness and thoroughness of action, firmness and impartiality, coupled with good judgment, are desirable and necessary on the part of the board

in promoting healthful measures and in seeking to resist the encroachments of disease; and if, as has recently been stated, "in their zeal for the public welfare they trespass upon the liberty of the individual," their effort in itself is none the less praiseworthy.

North Attleborough.

The subject of erecting a building for the purposes of a hospital or infirmary has been briefly considered by the town during the past year. Since the opinions there expressed were not entirely unfavorable to the idea, the board of health would state some of the reasons that ought to have weight in considering the propriety as well as the feasibility of the erection of such a building.

First. — It will furnish an undoubted means for the prevention of the spread of infectious diseases. Many of our tenement-houses are so arranged that the isolation of the sick one cannot be secured. There must necessarily be more or less contagion from the impossibility of preventing almost unrestricted intercourse between the sick and the well. The speedy removal of the affected patient to some suitable place would reduce the chance of contagion to a minimum; all intercourse between the sick one and the as yet unaffected other members of the family would be secured absolutely. The board of health found the greatest difficulty during the epidemic of scarlet fever occurring in 1892 and 1893 in securing the isolation of the affected ones among tenants of the tenement-houses; in some cases the arrangement of the rooms was such that it was impossible.

Second. — Economy to the family and to the town. By the removal of the affected patient, no quarantine of the entire family would be required. The father of the family would be allowed to continue his daily avocation, thus not interfering with his wage-earning capacity, and enabling him to continue to provide for the wants of the family and preventing his becoming a burden to the town. Again, the other members of the family could continue to pursue their usual avocations. The other children of the household would not be deprived of their school privileges, but would be allowed to enjoy the benefit of from two to six weeks of school instruction from which they might otherwise be debarred. The expense of a thorough disinfection of the premises would not be called for, thus doing away with a not small item in the account of tenement-house repairs.

Orange.

Forty complaints have been investigated and cared for by the board, beside many which are still pending the action of the board. The members individually have cared for many sources of filth and offence where no complaint has been made.

Palmer.

We have been called to examine cattle which have been affected with tuberculosis. Several have been killed; each one that has been examined and slaughtered has had the disease.

Pittsfield.

The possibility of being forced to provide again this spring a new dumping ground, or some form of disposal for refuse matter, is one that cannot be overlooked. Eight hundred loads of gravel have been drawn on the "dump," to cover refuse material; over three thousand loads of garbage, etc., have been deposited on the city's dumping ground. Hundreds of loads have been deposited on vacant lots by truckmen, who have been hired to convey the same to the "dump." The amount of material removed during the past year by the public excavator, in cubic feet, was: solids, 13,216; liquids, 5,358. The method of caring for night soil and cesspools seems to give general satisfaction.

Never before has the register of vital statistics been so complete as in the past year. All back burials are now recorded. It is the opinion of this board that the proposed law, prohibiting undertakers from being keepers of cemeteries, should be passed by the Legislature; as in the past, the practice has proved unsatisfactory in many ways.

The rendering establishment in the eastern part of the city, which in the past has been the source of complaint, has been rebuilt and a steam apparatus introduced, giving general satisfaction.

During 1894 the inspector of milk and cattle visited 164 herds of cattle and made 1,954 inspections. Sixty-two cases of tuberculosis have been discovered. Most of these cases were milking cows, and their milk was peddled in this city. These, with 32 cases last year, make 94 head that have been killed since June, 1893.

Provincetown.

There are now attending the public schools a good many children who have never been vaccinated, or at least not successfully. The time might come when this state of affairs would be a source of serious regret. The law of the Commonwealth on the subject is plain.

We would also call our citizens' attention to the fact that the number of private sewers is constantly increasing, and will in time, if it has not already, become a source of serious annoyance by contaminating our shores.

Quincy.

In September and since then there has been a large increase of diphtheria; this dread disease, more fatal and more to be dreaded even than small-pox, coming when least expected and from no known causes, has afflicted the

central portion of our city with greater or less intensity since its beginning. At the invitation of the board the doctors of the city met them, and, after a careful interchange of views, the board have adopted some of the suggestions made, and at this writing the city is practically free from the contagion. It may be well to record that in some of the later cases the antitoxine treatment has been tried with the best of results, and it is to be hoped that science has at last found a remedy, if not a preventive, for this alarming disease.

Reading.

The law enacted by the Legislature of 1894, which is "An act relative to the licensing of plumbers and the supervision of the business of plumbing," has been attended with some expense to the town, as well as all towns having a source of water supply, but in the opinion of the board will be repaid tenfold in the health of our people. Very few violations of those laws have occurred.

Revere.

There was not much scarlet fever and diphtheria in Revere till about the first of September; since then we had quite a number of cases, more of scarlet fever than diphtheria.

Salem.

Membership in the State Association of Boards of Health continues to be of decided value to this department. The special papers presented and subjects discussed afford opportunities for obtaining information of vital importance.

Nearly a year ago we changed the places of delivery of the garbage and refuse, so that with the former we can dump it at places easy of access and avoid stopping our teams on highways.

This board believes the spreading of scarlet fever and other zymotic diseases is occasioned by the thoughtless intermingling of members of afflicted households with other families, and to prevent the same some more stringent measure than those in vogue will have to be adopted.

Saugus.

A very large number of complaints have been made to the board to abate nuisances in the town. We have personally investigated each and every one, and in all cases where a nuisance was found they were ordered to abate the same, which has been done by every one ordered so to do.

Somerville.

Number of nuisances abated,	778
Number of nuisances complained of,	999

Eighteen cases of glanders and one of tuberculosis have occurred during the year. Prompt action was taken in every case, and the horses have been killed.

A series of carefully prepared tables, showing the deaths and death rates from several infectious diseases in the different wards of the city, is published in the report.

Taunton.

No change has been made in the method of collecting and disposing of swill and garbage. While there is certainly room for improvement in this matter, the time has not yet come for the outlay of a large sum of money to accomplish a work that is now costing the city nothing, and we can well afford to wait until a thorough trial of garbage cremation has been made in other places. In the matter of disposing of night soil the demand for reform is more urgent, as the present method of dumping on the ground and ploughing in is certainly open to serious objections.

At the request of the school committee an examination into the sanitary condition of all the school-houses in the city was made during the summer vacation.

There has been comparatively little scarlet fever and typhoid fever, but a great deal of diphtheria. Never since diphtheria was required to be reported have there been so many cases reported in so short a time. At the same time, the percentage of deaths has been very high. This epidemic of diphtheria ought to teach us several important truths, first of which is the urgent need of a hospital for contagious diseases. Perfect isolation is the only measure of checking or preventing the spread of diphtheria. This is obtainable only in a hospital constructed and carried on for the purpose. It is true that in the houses of our well-to-do people fairly good isolation can be and often is maintained; but in the tenement-houses, where a large majority of the cases occur, isolation of the patient is an absolute impossibility.

Tewksbury.

In the early spring several cases of diphtheria, and later in the season several cases of scarlet fever, were reported and placarded in different sections of the town, all of which were examined, and on recovery of patients a thorough fumigation of the premises was given.

Late in the fall a petition was sent to the board, remonstrating against the rendering establishment owned and operated by Darius Whithed. In compliance with the said petition a hearing was given to the remonstrant, and, after careful inspection of the premises by the board and the inspector of the State Board of Health, it was declared to be a damage to surrounding property and injurious to health. In accordance with that decision notice was served on the owner of said establishment that on and after Feb. 28, 1895, the said rendering business in this town will be prohibited.

Waltham.

The physicians of Waltham were notified by the board that they could have a bacteriological test made in all cases by applying at the office of the board. For a short time the microscopical work was done gratuitously, but as the work increased, owing to the appreciation of its benefits, the authorities of the medical school notified the board that a charge of three dollars would be made for each examination. In this emergency the Waltham hospital came forward and offered to fit up a laboratory for the examination of the cultures. For a while this was done, and Dr. Chadwick took the cultures and made the microscopic examinations at the hospital. The work continued to increase to such an extent that Dr. Chadwick was unable to attend to it, and on Jan. 11, 1895, the board voted to appoint Allen Greenwood, M.D., to be physician to the board of health, and to place him in charge of the contagious disease department. The board also voted to keep patients isolated in all cases of diphtheria until a negative bacteriological result was obtained, that is, until the microscope showed that no diphtheria bacilli were left.

It was during this year that the practical application of the discovery of a diphtheria antitoxine was made in Europe, and this board, realizing its probable advantages, made preparations to obtain some and give it a trial as soon as possible. The board was fortunate enough in December to obtain some of the first lot available in this country, and it was immediately used, with unquestionable benefit. Since then it has been supplied to physicians and the hospital by the board free of expense, and has proved effective to the extent that the only deaths since the first of December were the three occurring during the week that antitoxine was not obtainable. Thus, with the bacteriological test as an accurate method of diagnosis in all cases, and diphtheria antitoxine for the treatment of the severe cases, this board feels that it now has the means for reducing the mortality of this disease to a very low point. It is well here to emphasize the fact that, in order to get the most benefit from the antitoxine, it must be used early. Another good thing which has been accomplished this year is in requiring teachers in the public schools to dismiss all children suffering with throat troubles, and requiring a certificate from this board or from a reputable physician before their return. A considerable number of incipient and mild cases of diphtheria were in this way discovered and properly isolated.

In view of the possibility of an epidemic of small-pox, the board opened two public vaccination stations. There were 353 persons vaccinated at the Main Street station, and 205 at the Cutter Street station, — a total of 558.

Waltham is to be congratulated on its almost complete immunity from typhoid fever, there being but 13 cases reported this year. During the past twenty-two years Waltham has had fewer cases in proportion to the number of inhabitants than any other city in the Commonwealth, and this

excellent showing is evidently the result of the purity and general use of its public water supply. Most of the cases that have occurred can be traced to infected well water, and, knowing this, the board has endeavored to see that its regulations in regard to wells are enforced.

Since the new contagious hospital was built by the city the Waltham hospital has greatly enlarged its accommodations for contagious cases, with the result that the board will now be seldom required to adopt the expensive expedient of running a hospital on its own account. Yet the city has performed a duty in erecting the contagious hospital; for, although cases can be cared for much more cheaply at private institutions, there should be just such provision as the city has made for those emergencies when we cannot obtain the services of such institutions. There have been treated at the Waltham hospital 27 cases of scarlet fever and 31 cases of diphtheria.

Ware.

On account of the prevalence of small-pox in Chicopee, Holyoke and elsewhere in the State, in May last, it was deemed best that examination of all the schools should be made, and the children needing it vaccinated. The expense of the work was mainly borne by the town. The Otis Company and the George H. Gilbert Manufacturing Company, during the summer, also required revaccination of all their employees.

There has been no serious epidemic here during the past year, and no deaths reported from scarlet fever, measles or diphtheria. Jaundice prevailed during the fall in such a way as to be considered epidemic. Whooping-cough has traversed the town generally during the past six months, with less than ordinarily serious results, 3 deaths only being reported therefrom.

It is very fortunate that there have been no cases of hydrophobia among our population, as fifteen head of cattle here and seven more just over the Enfield town boundary line have been lost with that disease during the last summer. A strange hound, in the early part of April, bit a farm dog used in driving cows, and on May 11, this dog became mad and disappeared from his home, on which date two dogs, probably but one of them affected with hydrophobia, coursed through the north-western part of the town biting cattle only, then disappearing in the woods. In from twenty-two to twenty-nine days afterward nine of the cattle bitten died of hydrophobia; one lived forty-seven, another sixty-eight, days after being attacked. Only one other dog became mad during the year, and that, at its home in the village, was killed by the inspector.

Warren.

The past year has been unusual in the history of the town for prevalence of contagious disease. There have been 41 cases of typhoid fever. Fortunately the disease was generally of a mild character, only 5 having died. We have investigated each case, as it occurred, carefully, and, so far as we

could discover, have decided that it depended upon some local cause. In several instances where there has been a large number of cases in one family, and not extending to other families in the near vicinity (subject to the same influences), the spread of the disease was clearly dependent upon want of caution and cleanliness in the care of the sick. With our present system of cesspools and wells we must be liable to the prevalence of disease which would be prevented by a more intelligent disposal of our sewage. We hope the town at its coming annual meeting will take some action looking to a comprehensive and systematic system of sewerage, and that this action will precede the introduction of any general water supply for domestic purposes.

Wellesley.

No cases of typhoid fever have been reported to the board during the year. Six instances of nuisances have been complained of, all of which, with one exception, have been remedied.

Westfield.

At a town meeting, held April 6, 1893, you *Voted*, That the Board of Health is hereby instructed to compel persons owning, leasing or maintaining any building to connect with the public sewer, as provided in chapter 132 of the Acts of 1890, on or before the first day of January, 1895.

Your board construed this vote as mandatory, and have endeavored to enforce it with strict impartiality. Frequent and urgent notices were sent out, and, as a final resort, legal measures were served at the hands of a constable. Entrances were made from the opening to the closing of the season as rapidly as property owners could secure attention from the plumbers.

Sixty-eight written complaints have been made to the board, and in each case we have personally inspected the premises complained of, and where nuisances were found ordered them abated. We have also abated many nuisances where no complaint was lodged.

Westford.

The town has been reasonably free from infectious diseases, although scarlet fever has prevailed in a mild form, more or less, during the year. Two fatal cases of typhoid fever occurred in Graniteville, all in one family. Two others of the same family contracted the disease, but were removed to the hospital in Lowell and recovered. Investigation was made to trace the origin of the disease. The buildings and their surroundings were examined and the water from the wells analyzed, but nothing of a typhoid character could be found, and from the best information we are confident it originated outside of this town.

Upon receiving notice of a contagious disease we have at once quarantined the premises by posting cards of warning, which have been respected

very generally by the parties affected and the public. A few cases have been reported to us where these notices have not been complied with, where the inmates as well as their neighbors have mingled together too freely, and by so doing tend to spread the disease as well as to alarm the neighborhood. It should be understood that a notice of a contagious disease is put up for the purpose of isolating, as much as possible, those affected and the immediate family, and no one should go into the quarantined buildings unless he is obliged to do so on account of furnishing supplies or other necessities.

Weston.

Several nuisances have been attended to, but in one or two instances the parties evinced a disposition to make as little improvement as possible, and this board feels that in such cases severe measures should be employed in the future.

There has been much complaint the past summer in regard to the feeding of city swill, and we think that unless more care is taken it will be necessary to forbid the use of it entirely during the hot weather.

Whitman.

In many instances people have found fault with the board for placarding their houses, and in many others the board has been condemned for not being more strict.

Demands have been made that adult persons living in the same family with a light case of scarlatina should be kept from going to their work in the factories; but the board decided that, after posting warning cards and notifying as above, they would go no further unless in case of special complaint, this being more than had ever been deemed necessary in a country town before.

Winchester.

Care has been taken by the board of health to prevent the spread of contagious diseases. School-houses have been fumigated with more than ordinary care whenever two or more cases have been reported from them. We have also given personal attention to the fumigation of the houses in which severe or fatal cases of diphtheria or scarlet fever have occurred.

The attention of the school committee has been called to the custom of daily distribution of books, slate pencils, rubbers and sponges, and we believe that this custom has been corrected to some extent, but we still feel that it is a most prolific means of spreading contagious diseases, and should be done away with entirely. Each pupil should own and use his own books, sponge, pencils and rubber, and it would be wisdom for the town to furnish such materials free to all who cannot afford to buy, and to let others buy their own. We believe also that it is very desirable frequently to remove dust from the school-rooms by wiping floor and furniture with a damp cloth, time having been allowed for the dust in the air to settle undisturbed.

WINTHROP.

The tank at Short Beach has been used for receiving the material taken from cesspools and vaults, the same as for the two previous seasons. We have had no trouble with the receiving tank. It has proved to be a very easy, inexpensive and the most unobjectionable way of disposing of the material taken from the cesspools and vaults in the parts of the town where we are as yet without a public sewer.

The general work of the board the past season has been unusually large, and the importance of a health department is made more manifest every year as our beautiful town increases in population.

Various buildings found in an unhealthy state during the past season were ordered to be put in good sanitary condition. A large number of complaints of various kinds were made to the board, and all were investigated without delay, and where any nuisance was found to exist it was promptly ordered abated.

The regulations of the board appeared for the first time in neat pamphlet form, making them more convenient to handle, and, as each regulation was placed under its proper heading, reference to the same was made easy.

The health of the town the past season has been remarkably good.

WORCESTER.

Number of complaints for the year ending Dec. 31, 1894, 1,476. Rooms fumigated, 584.

To render more certain the diagnosis in cases of diphtheria, the board of health established, in September last, a bacteriological department. This department has already justified its introduction during the short time it has been established, many cases that the physician in attendance did not recognize as diphtheria proving to be such, and many others which were thought to be so proving on examination to be simply tonsillitis. The families in these latter cases were saved annoyance and expense, to say nothing of the anxiety and dread they were spared; while in the former cases the early detection of the dread character of the disease gave opportunity for instituting means to check its ravages and prevent its spread. Since the establishment the physicians of the city have generally availed themselves of its aid.

It is to be hoped that no unnecessary delay will occur in providing the accommodations required for isolating cases of contagious diseases. If unnecessary delay does take place, the question naturally arises, Would not the city be liable for the expense and injury done to the business of a hotel keeper, for instance, by an outbreak of contagious disease among his guests or employees and the consequent stoppage of the business; or, again, if an outbreak should occur in any of the educational institutions of the city, in consequence of which the school would be forced to close, would not the city be liable?

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